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Horological Diſquiſitions, Diſcovering the True Nature

Heath. Aug: OF 20th 1723.

TIME.

OR,

The Reaſons why all Days from Noon to Noon are not alike Twenty-four Hours long.

WITH

Tables of Equation, that ſhew the different Length of all Natural Days, and Newer and Better Rules than any that have been yet made Publick, for the moſt Exact and Nice Adjuſting of Pendulum Clocks and Watches.

The Second Edition, much Corrected, and many New Particulars added.

By *JOHN SMITH*, C. M.

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To which are annexed the beſt Rules for the Right Ordering and Uſe of Quickſilver and Spirit Weather-Glaſſes; and Mr. *Sam. Watſon*'s Rule for Adjuſting a Pendulum Clock by the Fixed Stars.

London: Printed for *John Nicholſon* at the *King's-Arms*,
and *John Sprint* at the *Bell*, in *Little-Britain*. 1708.

BRITISH MUSEUM

TO THE
READER.

THE only Deſign I had in firſt publiſhing this Book was to demonſtrate as plainly as I could the true Reaſon of the Inequality of Time, as it is divided naturally into Days, that I might ſhew thereby why a well-made Pendulum Clock could not be brought to ſuch a Pitch of Motion as to agree always with a good Sun-Dial; and to give ſuch Rules as by the Help of an Equation Table, which ſhews the different Length of Natural Days, accounted from Noon to Noon, might enable Gentlemen to adjuſt their Clocks to the trueſt Pitch of Motion 'tis poſſible to bring them to; in the doing of which I did then endeavour to expreſs the Senſe I had of the Inequality of Time, and the Way of adjuſting a Clock moſt truly in ſuch Words as I did judge would beſt inform the Reader's Under-

ſtanding, Plainneſs being always beſt where the Inſtruction of another is intended.

Now theſe Books firſt printed being all Sold off, and Enquiry being ſtill made after them, which ſhews they were well accepted of among the Gentry, the Bookſeller did deſign another Edition, and in order thereunto he did requeſt that I would reviſe the Work, that ſo, if poſſible, it might be made more perfect and compleat. Now according to his Deſire I have taken Pains to Correct the ſame in ſeveral Places, my Experience ſince having made me capable of expreſſing ſome Particulars more plainly, ſo that now I have made it much more eaſie to be underſtood, I have alſo added many Particulars, not incerted in the former Edition; and in particular I have, inſtead of the Second Table, formerly printed, put another in its Place, more eaſie to be underſtood by all Capacities, and of greater Uſe in the true adjuſting of a good Pendulum, and keeping it afterward as near as poſſible to the Time given by a Sun-Dial. I have alſo Corrected the Firſt Table, to make it agree more nearly to Experience, which is the Beſt Perfecter of any Art or Science; for I am fully ſatisfied from what I have obſerved, *ed, that the Equations given by Calculation are not nicely exact, tho' they are very nearly true, the Difference given by moſt Tables of Equation, already made publick between the true 24 Hour Day, and thoſe Days which are longeſt or ſhorteſt, being ſuch as by the Nice Obſervation of a well-adjuſted Pendulum appear to be too much near the greateſt Extremities.*

As for that Part of the Book which concerns the right Ordering and Uſe of the Weather-Glaſs, it is what all Gentlemen by Experience will find to be true, for I did not write any thing relating to it but what I was certainly aſſured of by my own Practice and Obſervation, and therefore I will be bold to profeſs thus much, that the whole Book is the moſt exact Piece in its kind that is extant in the Engliſh *Tongue, and I humbly hope will be eſteemed of accordingly by others.*

All that I have now to add is, that I could heartily wiſh, ſince I have taken ſo much Pains to ſhew the Way to adjuſt a good Pendulum Clock or Watch, that the making of good Clock and Watch-Work by the moſt Ingenious Workmen might be more encouraged, as in Reaſon it ought to be, not *only by Gentlemen, but by Merchants alſo, yet of late Years the contrary has been the moſt common Practice, for moſt Gentlemen do ſuppoſe, but without good Reaſon, that 'tis their chiefeſt Intereſt to Buy Clocks and Watches as cheap as they can; and therefore for want of Judgment to know Good from Bad Work, they trudge up and down from Place to Place, to ſee who will Sell at the cheapeſt Price, not conſidering as every Man, who underſtands the Matter rightly, will do, that the Beſt Work is the Cheapeſt, tho' at the firſt it coſt deareſt, becauſe Good Work will go much truer, keep better in Order, and laſts longer than that Bad Work will do, which is made by Unskilful or by Diſhoneſt Men, that they may Sell it at the loweſt Rates, which after a few Years, if not a few Months going, will but prove a Plague to them that have it, becauſe moſt commonly out of Order, ſo that the Mending Charge will make it dearer to the Poſſeſſor than a good Piece of Work would have been; yet this but few Gentlemen do conſider, and therefore they chuſe to encourage thoſe Bad Workmen moſt who Sell for the Smalleſt Price, which in a little Time, if common Prudence make* *no Alteration in their Practice, will reduce the Beſt Workmen, who have little to do in their Way of Working, to ſuch a low Condition, as will make them neglect that Ingenuity and Curioſity which is neceſſary to be found in the making up of a good Clock or Watch; for Men will never take Pains to make up their Work true and ſound when they cannot be paid for the ſame, but muſt Sell it for as little as thoſe do who either cannot or will not make the like Work.*

And the ſame Decay of Good Workmen will be cauſed alſo by the too common Practice of many Merchants, who think they can get moſt by what they Buy cheapeſt; but this is a grand Miſtake, for as bad Work will never perform ſo well beyond Sea as that which is good, ſo it will follow by Conſequence, as many have found by Experience, that a Merchant who Sells bad Work, which is bought cheap, will never keep his Credit long in One Place, and therefore will get much leſs by bad Work than he would have done by that which is good; for by Selling Watches and Clocks that are well made he will get the Credit of a Fair and Honeſt Dealer; and a clear Credit not only finds the beſt Cuſtomers, but will Sell the *moſt, which in the end will turn to the beſt Account; but it will be quite otherwiſe when Merchants Buy that only which they can have for the ſmalleſt Price. 'Tis well known at this Day to ſome, that ſo much baſe Work hath been ſent into ſeveral Parts of* Turky, *by which many have been cheated, that the* Turks *begin to be very cautious, and will not Buy any thing of this Nature till they have firſt had Time to try it; upon which Account many ill-made Clocks and Watches have been returned, to the great Damage of them that ſent them; and I doubt not but this has been the Caſe alſo of ſome Merchants who have traded with ſuch Traſh into other Parts, or at leaſt will be ſo in a little Time, if they continue to ſend that which is Cheap, rather than that which is Good, as too many now do, to the Diſcouragement of the moſt Ingenious Workmen; who being ſlighted becauſe they cannot Sell ſo Cheap as others, will be reduced to a ſtarving Condition, and by this Means, as before was ſaid, the Perfection of the Art of Clock and Watch-making, will be in danger to be loſt; for Men will never continue to work well if they cannot Live by it, or Sell their well-made Work for more than* *that Work is Sold for, which is made by Bunglers and Botchers, which alſo in Time will make Clocks and Watches ſo contemptible in all Parts, that but few will eſteem them, and ſo the Trade, as well as the Curioſity of the Art, will be quite loſt together, which might both be preſerved by encourageing thoſe moſt who Sell good Work, inſtead of encouraging thoſe moſt whoſe Work is Cheap and Bad, as the moſt common Cuſtom now is, there being now ſcarce One in Forty Bought that bears a Price ſuitable to that which deſerves to be accounted Good, which is an undoubted Sign that the Art will ſoon be at an end, when the Way of making Good Work is ſo much neglected, and the other ſo much encouraged.*

And when the Art of making Good Work is once loſt in England, *as the Art of making Good Watches is now loſt in* Geneva, *which Place was once Famous throughout all* Europe *for the making of Good Work, till they began to grow very numerous, and by the too great Increaſe of Workmen were neceſſitated to Underſel one another to get Bread, which in a little time did occaſion the making of ſuch Bad or Slight Work among them, that they loſt their Credit ſo* *far, that ſcarce any one in* Europe *will now Buy a Watch if he knows it to be made at* Geneva: *I ſay, when the Art of making Good Clocks and Watches is loſt in* England,*as the Art of good Watch-making is loſt at the Place before mentioned. My Tables of Equation will not be of ſo much Advantage to thoſe who ſhall then Buy ſuch Bad Clocks and Watches as they will be to thoſe who have ſuch as are well made, it being impoſſible to adjuſt a Bad Piece of VVork ſo nicely, as ſuch VVork may be adjuſted which is well made by a Skilful Hand.*

Horological Diſquiſitions.

AS Time, in which the Sun continues to run his Race, is divided naturally into Years and Days, by the Two different Motions of that luminous Body; ſo Mankind has been induc'd by their reaſoning Faculty to divide the Day into Parts, called Hours, and Hours into Minutes; and as the exceeding great Uſe and Benefit of this Diviſion is now known to many Nations, ſo in the moſt civilized Parts of the World Men have been ſtill contriving Ways how to do this with the greateſt Exactneſs.

The firſt and moſt ancient of all was doubtleſs that of Sun-Dials; a Noble Invention, but yet defective, in that it is of Uſe no longer than the Sun ſhines: The next to this, of any Value and

Eſteem, was that of the Hour-Glaſs; an Excellent Contrivance, if we conſider its Uſefulneſs at all Times; but the Care required to keep it in continual Motion did ſtill excite the Ingenious to endeavour after the Diſcovery of ſomething elſe that might not only be more exact, but free too from the continual Toil, as I may call it, and Trouble of Attendance.

In Proceſs of Time this came to be performed in Part by the Way of Clock-Work; a Device firſt of all ſtarted among the *Germans*, from whom the Art of making Clocks diſperſed itſelf over other Parts of *Europe*, but very defective at firſt as to its exact and ſteady keeping of Time: At length, in *Holland*, an Ingenious and Learned Gentleman, Mr. *Chriſtian Hugens* by Name, found out a Way to regulate the Uncertainty of its Motion by the Vibrations of a Pendulum.

From *Holland* the Fame of this Invention ſoon paſt over into *England*, where ſeveral Eminent and Ingenious Workmen apply'd themſelves to rectifie ſome Defects, which as yet was found in Mr. *Hugens*'s Invention ; among which that Ingenious and Eminent Artiſt, Mr. *William Clement*, did give it at laſt the finiſhing Stroke, he being indeed the Real Contriver of that long Pendulum, which is at this Day ſo univerſally in Uſe among us.

An Invention that exceeds all others yet known, as to the Exactneſs and Steadineſs of its Motion, which proceeds from Two Properties peculiar to this Pendulum: The one is the Weightineſs of its Bob, and the other the little Compaſs in which it plays: The firſt of theſe makes it leſs apt to be commanded by thoſe Accidental Differences of Strength that ſometimes happens in the Draught of the Wheels, and the other renders the Vibrations more equal and exact, as not being capable of altering ſo much in the Diſtance of its Swing, as thoſe other kind of Pendulums are who fetch a larger Compaſs.

For Pendulums that ſwing or vibrate very far out, as all Crown-Wheel Pendulums do, are apt to vary much in the Diſtance they ſwing, and that's the reaſon they do not always go or move the ſame Pace, a larger Vibration in the ſame Pendulum taking up more Time to be performed in than leſſer ones do: But the Vibrations of this Pendulum of Mr. *Clement*'s Contrivance is ſo very exact and ſteady, that when 'tis well in Order, and the Air of the ſame Conſiſtence and Temper, it ſhall in Five Hundred or a Thouſand Revolutions of its Index, or Hand, keep ſo equal a Time, that no Humane Art can diſcover the leaſt conſiderable Difference in any of its Revolutions, an Excellence to which no other known Motion can as yet pretend, and for which I think it will not be improper now, at laſt, to give it the Title of the *Royal Pendulum*.

But although the Motion thereof be ſo very curiouſly exact and equal, yet 'twill not for all that regulate the Motion of a Clock in ſuch a manner, as that the Index or Hand ſhall continually agree with that Time which the Sun gives on a good Dial; for by conſtant Experience we find, that the beſt of Clocks, when exactly adjuſted, will yet be found in ſome conſiderable Number of Days to be either too faſt or too ſlow for the Sun, although it was before ſet right therewith.

Now this Diſagreement cannot be occaſioned by any Defect in the Motion of the Pendulum each Twenty-four Hours, of which, throughout the Year, when well rectified, being the very ſame for length of Time, but it does proceed from an Irregularity in the Sun's apparent Motion, which does occaſion a great Diverſity in the Lengths of Natural Days. 'Tis generally believed indeed that the Natural Day, or the Time between 12 and 12 a Clock at Noon, is always in Length juſt 24 Hours: But this is a great Miſtake, for it will appear by the following Accounts of it that it is but in ſome Parts of the Year that the Days are juſt 24 Hours long, and that in all the other Parts, between theſe Days, they do continually differ, being ſometimes above 24 Hours long, and ſometimes leſs; and though the Differences may ſeem but a ſmall Matter to ſome, the greateſt Exceſs being not above 30 Seconds, or half a Minute, yet if theſe, ſeemingly but little Differences, be added together for the

Space of a Month or Two, they will amount to a very conſiderable Sum of Time.

Now, to make the Reaſon of this Irregular Length of Days as plain as I can, take notice, That as Natural Days are that Space of Time, in which the Sun (or, as others think, the Earth) that divide Time into Days, is moved round juſt One whole Diurnal Revolution, or paſſes from the Meridian, or Twelve a Clock Point of One Day to that of the next; ſo it muſt follow that all ſuch Natural Days cannot be of a true and equal Length, unleſs the Sun in that Space of Time did alſo move in ſuch a manner, as that the Equinoctial may be always divided into equal Parts by thoſe Meridians, on which the Sun is upon each particular Day: But that this is not done is plain to all that are verſt in Aſtronomy, and do rightly underſtand the Uſe of the Globe.

For by an exact Table of the Sun's Right Aſcenſions 'twill be found that the Meridian Sun of each Day doth not divide the Equinoctial into ſuch equal Parts, their Differences being unequal, but more on ſome Days than they are on others; and theſe their Differences will appear yet more plain and viſible, if you will be but at the Pains to compute what the Right Aſcenſions in 10 or 20 Days Time amount to in ſome Parts of the Year, and compare that with the Right Aſcenſions of the like Number of Days in ſome other Part.

This will be viſible to the Eye, if on the Globe you mark out on the Ecliptick 10 or 20 Days Motion of the Sun, as 'tis found ſet down in an exact Ephemeris or Almanack, which ſhews the Sun's true Place; and paſſing this Space thus marked under the Brazen Meridian, do note what Number of Degrees on the Equinoctial are included in it; the which compare with the like Number of Days Motion in ſome other Part of the Ecliptick, and the Degrees ſo compared will be found to differ, or be more in number in ſome Places than they are in others, which plainly demonſtrates the Thing aſſerted.

Now the Reaſon of theſe Differences in the Right Aſcenſions, and by Conſequence in the different Lengths of Days, proceeds, in the Firſt Place, from the Croſs Poſition of the Zodiack and the Equinoctial Lines, as before was ſaid, which on Globes do repreſent the Circles of the Sun's Yearly and Daily Motion; for the Courſe of the Sun's Daily Motion being directly from Eaſt to Weſt, and the Circle of his Yearly Motion or Zodiack being in Poſition Croſs-ways thereunto from the almoſt South-Weſt to the North-Eaſt, as by the Globe is apparent to the Eye, it follows that the Right Aſcenſion will be ſtill unequal; for 'tis impoſſible that the Sun, in his Motion, near *Aries* and *Libra*, where the Zodiack lyes ſo croſs to the Equinoctial, ſhould in any certain Number of Days make the ſame Number of Degrees in Right Aſcenſion, as it will do near the Two Tropicks of *Cancer* and *Capricorn*, where the Ecliptick runs in a manner parallel to the Equinoctial Circle, and not in ſuch a Croſs Poſition, as it does near the Equinoctial.

And accordingly 'tis found by the beſt Tables of Right Aſcenſion, that the Right Aſcenſions belonging to 10 Days Motion of the Sun, near the Tropick of *Capri-*

Capricorn, amounts to about 11 Degrees 30 Minutes, whereas that of the ſame Number of Days, near the Equinoctial Points of *Aries* or *Libra*, will be found to be hardly 9 Degrees.

Moreover, as the Right Aſcenſions near the Tropicks differ from thoſe near the Equinoctial Parts of the Ecliptick, ſo the Right Aſcenſions of One Tropick does differ from that of the other: Now the Cauſe thereof differs from the Cauſe of the former Unequalities, for this proceeds from the Excentricity of the Centre of the Earth, and the Centre of the Sun's Yearly Orb; for the Centre of the Earth, on which we live, not being the ſame with the Centre of the Ecliptick, in which the Sun moves, but diſtant from it about 316000 Miles, as ſome Aſtronomers affirm, it follows that there muſt be a greater Part of the Sun's Orb on one Side of the Centre of the Earth than there is on the other; for which Reaſon, tho' the Sun moves equally each Day in the Circle of his Yearly Courſe, yet to us it ſeems to move faſter in ſome Parts thereof than it does in others, and that makes the Right Aſcenſions greater near One Tropick than they are near the other.

And accordingly, by the Tables of the Sun's Motion, 'tis found that it takes up but about 179 Days in paſſing that Part of the Ecliptick between *Libra* and *Aries*, whereas between the Two Points of *Aries* and *Libra* it ſpends above 186, ſo that the Sun is almoſt 7 Days more in paſſing the *Summer* half of the Ecliptick than in paſſing that of the *VVinter*, and this ſeemingly ſwift and ſlow Motion of the Sun is the Cauſe that the Right Aſcenſions of 10 Days Motion near the *VVinter* Tropick are 60 Minutes, or a whole Degree more than thoſe of the ſame Number of Days near that of the *Summer* one.

The Right Aſcenſions of 10 Days Time near the Two Equinoctial Points do alſo differ ſomewhat; for thoſe of 10 Days Time, near *Aries*, are leſs by 30 Minutes than thoſe near *Libra*; the Reaſon of which is from hence, that the Sun's greateſt and neareſt Diſtance to the Earth happens now in our Times to be about 8 Degrees, and ſomething more from the Tropick Points, whereas had it fallen out exactly in the Two Tropicks, then the Right Aſcenſions near the Two Equinoctials would have been both alike.

Now, by what has been ſaid, I hope the true Reaſon of the unequal Lengths of Natural Days will plainly appear to all who underſtand the ſame, and by Conſequence Men will not hereafter be ſo unreaſonably Nice and Curious, as ſome have been heretofore, to expect always an exact Agreement between their Clocks and the Sun; for if there be from the Nature of the Fabrick of the World, and the Celeſtial Orbs above us, ſuch a Neceſſity for thoſe Differences, as are found in the Sun's Right Aſcenſions, and there being for that Reaſon a Neceſſity alſo that the Days bounded thereby ſhould be unequal in Proportion to thoſe Differences, 'tis then plainly impoſſible that a Royal Pendulum, *whoſe Diurnal Revolutions are always equal, and, if well adjuſted, gives you the true Time of* 24 *Hours*, ſhould agree with the Sun, which makes the length of Days almoſt continually to differ, and to be ſometimes more than 24 Hours long, and ſometimes leſs.

☞ For, in the firſt Place, this makes it impoſſible to adjuſt a Clock well barely by the Sun For ſuppoſe one ſhould attempt to adjuſt a Clock when the Natural Days are not fully 24 Hours long, as about the middle of *March*, where, as appears by the firſt of the following Tables the Day wants 20 Seconds of 24 Hours long, this Clock, when brought to go correſpondent to the Days in *March*, ſhall in ſome Part of *June* finiſh his Pendulum Day, *or his* 24 *Hours Revolution*, before the Sun ſhall compleatly paſs between one Meridian and another, that is, before the Sun ſhall paſs from the Hour of 12 one Day, to that of the Hour of 12 on the next, becauſe now the Natural Day is longer than 24 Hours by 13 Seconds, whereas the Day to which it was before adjuſted was 20 Seconds ſhorter than 24 Hours, and by Conſequence the Pendulum Day of a true Clock muſt be finiſhed ſooner in *June* by 33 Seconds than the Natural Day, and gain each Day 33 Seconds in Time.

On the contrary, if a Clock could be adjuſted to the Sun in the Month of *December*, at which Time the Natural Day is longeſt, being then 30 Seconds, or half a Minute above 24 Hours in length, this Clock, when Natural Days are ſhorteſt, as in *March*, where they want about 18 or 20 Seconds of 24 Hours, this Clock, I ſay, ſhall not then finiſh his Diurnal Revolutions in ſo little a Time as thoſe Days ſhall, and by Conſequence the Clock ſhall go each Day 48 or 50 Seconds too ſlow, which is almoſt a Minute, becauſe thoſe Days in *March* are ſhorter by 50 Seconds than thoſe in *December*, to which your Clock is ſuppoſed to be adjuſted.

Suppoſed to be adjuſted, I ſay, for to adjuſt a Clock exactly by the Sun, without the Help of a Table of Equation, we affirm to be impoſſible, becauſe the Length of Days continually altering, he that would adjuſt a Clock to the Sun muſt be always altering of it accordingly; and if he ſhould accidentally bring it to go ſlow enough, as he thinks, for ſome Days, ſuch as thoſe long ones in *December* are, the Length of the Day ſoon altering, and becoming ſhorter, he muſt again alter the Length of his Pendulum, to make it go equal to Days that are now ſhorter, and ſo not underſtanding the Nature of Time truly, nor of what Length a mean or middle Day is, he will, in Hopes of making it go always true, be continually altering of it, as he ſees it vary, and that without ever being able to make it keep the Time deſired; for 'tis impoſſible a Motion that keeps always the ſame Time that its particular Length or Pitch of Pendulum does admit of, can be ſo adjuſted by the bare Sun, as to accord therewith in all thoſe various Lengths of Days, which are made by its either ſlow or ſwift Motion.

Since then Things are thus, it remains that we ſhew how by Art that may be done which by meer Natural Obſervation can never be effected; that is, by what Means a Clock, regulated by a Royal Pendulum, may be adjuſted to ſuch a middle Pitch of Motion as to make in a compleat Year 365 equal Revolutions, or go ſo that each of its 24 Hours may be the ſame for Length as the 365th Part of a Year is, which is indeed the true Time of a 24 Hour Day, and that's the neareſt and the moſt exact Pitch to which 'tis poſſible to adjuſt the beſt of Pendulums.

Now this is only to be done by the Help of ſuch a Table of Equations which as nearly as 'tis poſſible ſhall give you the true Length of every Day, ſo that knowing by this Means not only which Days are truly 24 Hours long, but alſo which are ſhorter, and which are longer, and the Quantity of Time they are ſo, 'twill be eaſie then to know what muſt be taken from ſome Days, or added unto others, to make them equal to them that are truly 24 Hours long, which is our true Buſineſs in the Equation of Time: And though this cannot be done in the Natural Day itſelf, yet knowing how much all Days do differ from 24 Hours, the Motion of a Clock may yet be adjuſted thereby to a true Pendulum, or 24 Hour Day, by making it either loſe or gain ſo much each Day as the Days do exceed or fall ſhort of 24 Hours.

And this may be performed by the

Tables of Signs and Tangents, for by theſe you may readily frame a Table of the Sun's Natural Right Aſcenſions; and this ſhall ſhew you what Degrees of the Equinoctial are each Day upon the true Meridian when the Sun comes to it. Now theſe being in their Meaſure of Degrees and Minutes ſometimes more, and ſometimes leſs, you muſt next find out what a mean or equal Right Aſcenſion will amount to by dividing the 360 Degrees of the Equinoctial into 365 Parts, agreeable to the Number of Days contained in a Year, allowing for the Six odd Hours; then compare each Natural Right Aſcenſion with the mean Right Aſcenſion, and by ſubſtracting the leſſer from the greater, you will by turning the Differences between them into Time come to know their true Equation, that is, how much each Day is longer or ſhorter than 24 Hours; for ſo much as the Natural Right Aſcenſion is more in Time than the Mean Right Aſcenſion, ſo much is that Day longer than 24 Hours; and ſo much as the Natural is leſs than the Mean, ſo much that Day does want of 24 Hours.

But Men may now well ſpare themſelves the Trouble of doing this, in regard that Tables of Equation are already publiſhed by divers Men: As firſt, that publiſhed by Mr. *Hugens*, Printed in Numb. 49. of the *Philoſophical Tranſactions:* Secondly, that by Mr. *Flamſteed*, commonly made uſe of by Mr. *Tompion*, and generally Printed in *Parker*'s *Almanack*. Thirdly, by Mr. *Molyneaux*, in his Ingenious Tract concerning a *Teleſcope Dial:* And Fourthly, by Dr. —— in his Treatiſe, Entitled, *The Artificial Clockmaker*; in each of which Tables the Equations are very nearly the ſame for Subſtance, as you will ſoon find by ſubſtracting their Numbers from the greater next it; and 'tis not material which Table you chuſe, provided you underſtand it rightly; which there are not many that truly do however for ſome Reaſons which I ſhall not now mention, I have made Choice of Mr. *Hugens*'s Equations for the Uſes intended in this Work, and have caſt his Equations into ſuch other peculiar Forms of my own, as I judge more plain and natural for our Uſe than they are in the Form in which I find them publiſhed by him in the *Philoſophical Tranſactions*; and I believe will, by the Generality of them that have *Royal* or *Long Pendulums*, be better underſtood too.

Now in order to underſtand rightly this my firſt Equation Table for the true Length of Natural Days, take notice, that the firſt *Column* contains the Days common to every *Month*, and the other 12 *Columns* do belong to the *Months* whoſe Names are ſet over them; in the which Table *D*—24 denotes which Days in the *Year* are juſt 24 Hours long; and where you find both *Figures* and *Cyphers* parted with Two Points, as in the Months of *Jan. Jun. Jul. Nov. Dec.* &c. there the Days are ſo many Seconds of Time above 24 Hours long, as the Figures do expreſs; and where-ever the Figures are ſingle, or without Cyphers, and points as in the other Months, there the Days want ſo much of being 24 Hours long, as thoſe Figures which are Seconds of Time do amount to; ſo that by this Table you may diſcern by Inſpection at what Times of the

The Firſt Table of Equations, ſhewing the true Length of every Natural Day, or the Seconds of Time that the unequal Days are either longer or ſhorter than 24 Hours.

Mo.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.
1	0 : 24	D--24	17	17	3	0 : 11	0 : 7	9	20	14	0 : 9	0 : 28
2	0 : 24	1	17	16	2	0 : 11	0 : 7	9	20	14	0 : 10	0 : 28
3	0 : 23	2	18	16	1	0 : 12	0 : 7	10	21	13	0 : 11	0 : 28
4	0 : 23	3	18	15	D-24	0 : 12	0 : 6	11	21	13	0 : 11	0 : 28
5	0 : 22	4	18	15	D-24	0 : 12	0 : 6	12	21	13	0 : 12	0 : 28
6	0 : 22	5	18	14	0 : 1	0 : 13	0 : 6	13	21	13	0 : 13	0 : 29
7	0 : 21	6	18	14	0 : 2	0 : 13	0 : 5	13	22	13	0 : 14	0 : 29
8	0 : 21	6	18	14	0 : 3	0 : 13	0 : 5	14	22	11	0 : 15	0 : 29
9	0 : 20	7	18	14	0 : 3	0 : 13	0 : 4	14	22	10	0 : 16	0 : 29
10	0 : 20	8	18	13	0 : 4	0 : 13	0 : 4	15	21	9	0 : 17	0 : 29
11	0 : 19	8	18	13	0 : 4	0 : 13	0 : 3	15	21	8	0 : 17	0 : 30
12	0 : 18	9	18	12	0 : 4	0 : 13	0 : 3	16	20	7	0 : 18	0 : 30
13	0 : 17	9	19	12	0 : 5	0 : 13	0 : 2	16	20	7	0 : 19	0 : 30
14	0 : 16	10	19	11	0 : 5	0 : 13	0 : 1	16	20	6	0 : 20	0 : 30
15	0 : 15	10	20	11	0 : 5	0 : 13	D-24	17	20	6	0 : 21	0 : 30
16	0 : 14	11	20	10	0 : 6	0 : 12	D-24	17	20	5	0 : 22	0 : 30
17	0 : 13	12	20	10	0 : 6	0 : 12	1	17	20	4	0 : 23	0 : 30
18	0 : 12	13	20	10	0 : 6	0 : 11	2	18	20	3	0 : 24	0 : 30
19	0 : 11	13	20	10	0 : 7	0 : 11	3	18	19	3	0 : 24	0 : 30
20	0 : 11	13	19	10	0 : 7	0 : 11	4	19	19	2	0 : 25	0 : 30
21	0 : 10	14	19	9	0 : 8	0 : 11	4	19	19	1	0 : 25	0 : 30
22	0 : 9	14	19	9	0 : 8	0 : 11	4	19	19	D-24	0 : 25	0 : 30
23	0 : 8	15	19	8	0 : 9	0 : 10	4	19	19	D-24	0 : 26	0 : 29
24	0 : 7	15	19	7	0 : 9	0 : 10	5	19	18	0 : 1	0 : 26	0 : 29
25	0 : 6	15	19	7	0 : 10	0 : 10	5	20	17	0 : 2	0 : 27	0 : 28
26	0 : 5	15	19	6	0 : 10	0 : 10	5	20	17	0 : 3	0 : 27	0 : 27
27	0 : 4	16	19	6	0 : 11	0 : 10	5	20	16	0 : 4	0 : 27	0 : 27
28	0 : 3	17	19	5	0 : 11	0 : 9	6	20	16	0 : 5	0 : 28	0 : 26
29	0 : 2		19	4	0 : 11	0 : 9	7	20	16	0 : 6	0 : 28	0 : 25
30	0 : 1		18	3	0 : 11	0 : 8	8	20	15	0 : 7	0 : 28	0 : 25
31	D-24		17		0 : 11		9	20		0 : 8		0 : 24

In this Table where **D—24** is found, thoſe Days in the ſeveral Parts of the Year on which it ſtands are juſt 24 Hours long, but in all the other Parts of the Table, where there are Cyphers and Points added to the Figures there, each Day is ſo many Seconds long above 24 Hours, as thoſe Figures ſignifie; on the Contrary, where there are only Figures without Cyphers and Points there the Natural Days do want ſo many Seconds of being **24** Hours long; ſo that in viewing the Table you may perceive by the Eye in what Times of the Years a well-adjuſted Pendulum will gain or loſe, for it will gain where the Days are longer than 24 Hours, and loſe where they are ſhorter. *Note, That 60 Seconds make a Minute, and 60 Minutes make an Hour.*

Year the Clock will naturally gain or loſe, and by the Sum of the Figures you will know the Time in Seconds ſo loſt or got each Day.

The firſt Table being thus briefly explained, I will ſhew how by the Help of it you may adjuſt a Royal or Long-ſwing Pendulum to ſuch a Pitch of Motion as ſhall correſpond as near as poſſible to the true 24 Hour Day; now to do this let the Clock be ſet right to the Sun on ſome Day, and note the Day on which 'tis ſo ſet, then let it continue going for a Month, or more, and on ſome Day in which the Sun ſhines obſerve how the Clock and the Sun do agree, whether it be too faſt or too ſlow, and conſider alſo whether in the Time it has gone the Days are either longer than 24 Hours, or ſhorter; for if they are ſhorter than 24 Hours the Clock would have loſt if it were truly adjuſted. Now if it hath loſt juſt ſo much as the Sum of the Seconds belonging to all the Days it hath gone in between its firſt ſetting, and your preſent obſerving, it is well adjuſted, but if it hath loſt more, the Bob muſt be ſcrewed up ſhorter, to make it go faſter; or if it hath not loſt ſo much, the Bob muſt be ſcrewed down lower, to make it go ſlower, according as the Quantity of Time is that it hath got or loſt; on the contrary, if it ſhould be ſet at ſuch a Time of the Year wherein Clocks, when well adjuſted, will naturally gain, or go too faſt, you muſt then obſerve whether it hath gained juſt ſo much as the whole Sum of Seconds belonging to all the Days it hath gone in do amount to, by allowing 60 Seconds to a Minute, in your adding them together. For if it hath gained juſt ſo much, then is the Clock well adjuſted, or brought to correſpond with the true 24 Hour Day, which is ſhorter at ſuch a Time of the Year than the Natural Day is, *which the Sun makes in paſſing from the* South *Point, and coming to it again*, by juſt ſo many Seconds of Time as belongs to each Day, for ſo much muſt be added to each Day to make it a true 24 Hour Day; but if it hath not gained ſo much, you muſt then ſcrew the Bob up, to make it go a little faſter; on the contrary, if it have gained more you muſt ſcrew the Bob lower to make it go a little ſlower: After which ſet it right to the Sun, and obſerve it again, as you did before, till you have brought it to go near the Truth, for a Critical Niceneſs perhaps you will ſcarcely attain to, unleſs by Chance.

But note here, that when a Clock is pretty nearly adjuſted, and you do deſire to make it go yet more exactly, you muſt then ſhorten the Pendulum to make it go faſter, or lengthen it to make it go ſlower, but a very little, one turn of the Screw, or leſs, either one Way or other, in ſuch a Nice Caſe being ſufficient to alter a ſmall Difference, as will afterwards be ſhewed: Now when a Clock is exactly adjuſted, its daily Revolutions, or each 24 Hours given by it will be equal to the true 24 Hour Day, which is juſt the 365th Part of a Year, allowing for the odd Six Hours, which in Four Years make a Day; and ſuch a Clock as this, if ſet right to the Sun on any Day, and let go the whole Year round, without new ſetting, would come right again to the Sun the ſame Day Twelvemonth, did no other Accidents intervene, to which yet there is none but what are ſubject, eſpecially to that of the Change of Weather; for if the Weather of one Year be not exactly like the Weather of another Year, the going of a Clock ſhall be leſs exact in One Year than it is in another, its Motion being apt to vary with Heat and Cold, Wet and Dry.

However, if a Clock be ſo well adjuſted, that it would come right to the ſame Dial to which it was ſet a Twelvemonth before, yet in the middle Parts of that Year it will differ very much from the ſame Dial to which it was at firſt ſet, as will be apparent if we conſider *the Firſt Table*; for the ſame Clock, according to the Time of the Year it may be at firſt ſet right in, ſhall move ſo as to be either always too ſlow, or always too faſt; or it may be ſet at ſuch a Time that it ſhall go ſometimes too ſlow, and ſometimes too faſt. For Inſtance, if it be ſet right the 1ſt of *February*, it will loſe by the 4th of *May* above 19 Minutes, for ſo much the whole Sum of Seconds in that Time of loſing will amount to, *allowing* 60 *Seconds to a Minute*; after which it will begin to gain till the 16th of *July*, but the Time then gained is not much above 9 Minutes, ſo that it will be ſtill about 10 Minutes too ſlow; after which it will begin again to loſe till the 22th of *October* to the Quantity of 21 Minutes, and ſomething more, which with the 10 Minutes it was too ſlow at its laſt beginning to loſe, will make it now to loſe at leaſt 31 Minutes, or half an Hour, which it will get up again between the 24th of *October*, and the 2d of *February*, in which Time it will gain above 31 Minutes. On the contrary, if it were to be ſet at firſt on the 24th of *October*, it would gain between that Time and the 2d of *February* above 31 Minutes, and its next Time of loſing between the 2d of *February*, and the 4th of *May*, will amount but to a little above 19 Minutes, ſo that it will be ſtill 12 Minutes too faſt; after which, from the 4th of *May*, till the 16th of *July*, it will gain about 9 Minutes more, and be then too faſt 21 Minutes, which it will loſe between that Time, and the 24th of *October*, the Day on which it was ſet a Twelvemonth before, and ſo come right to the ſame Dial, *provided, as was ſaid before, that no Accidents intervene that ſhall interrupt its Courſe.* And by the ſame Table it appears that if a Clock were ſet the 6th of *May* it will be ſometimes too faſt, and ſometimes too ſlow, if let go without new ſetting the whole Year about; for from the 6th of *May* to the 14th of *July* it will gain above 9 Minutes, and from thence to the 21ſt of *October* it will loſe above 21 Minutes, and ſo be 11 Minutes too ſlow; after which it will get till the 2d of *February* above 31 Minutes, and ſo be 20 Minutes too faſt, which it will again loſe, and ſo come right by the 3d of *May*.

Such Variety then, according as it is ſet there, will be in the Motion of a Clock at ſeveral Times of the Year, if it be well adjuſted by the firſt Table; but becauſe there may be more Trouble in doing ſuch a Work by that Table than the moſt Part of thoſe are willing to be at, who yet deſire to have their Clocks go as exactly as poſſible, it being ſomewhat difficult for every one to add together the Seconds of Time to turn them in Minutes, I have therefore added a Second Table more plain, *tho' it does not ſo well ſhew the different Length of Natural Days, as the Firſt Table does, which by Inſpection ſhews which Days are juſt* 24 *Hours long, and which are either ſhorter or longer*; which

Second Table is formed out of the Equations contained in the firſt, by adding them together from the beginning down to the end of each Month, and the whole Sum is the Time that will be got or loſt by a well adjuſted Clock in each Month, if it be ſet right to the Sun on the Firſt Day.

Now to adjuſt a Clock by this Table do thus, ſet it right to the Sun the Firſt Day, and if it hath got or loſt at the end of the Month, the ſame Number of Minutes and Seconds as you find ſummed up at the Foot of the Table, under the Titles either of *Gain* or *Loſs*, it is well adjuſted; but if it either get more or leſs, the Bob then muſt be rectified, as before was ſhewed, to make it go faſter or ſlower; and whereas in ſome Months a Clock ſhould both gain and loſe, as in *May*, *July* and *October*, therefore in thoſe Months the Exceſs only, or Overplus of the Gain or Loſs, is ſet down at the bottom of the Column for that Month, as the true Time it ſhould loſe or gain, as in *July* the Gain is but 3 Seconds, and in *October* the Loſs is 2 Minutes, 19 Seconds.

And by this Table, when a Clock is well adjuſted, you may keep it nearer to the Time given by the Sun than by any other Table uſed by others; becauſe if you ſet the Clock backward or forward at the beginning of each Month, juſt the ſame Time that the Table ſhews it hath got or loſt in the Month preceeding it will be right with the Sun, tho' it ſhould not be poſſible to ſee the Sun to ſet the Clock right to a Dial by it; thus if on the 1ſt of *February* you ſet the Clock back the Time gained in *January*, which is 6 Minutes, 51 Seconds, it will be right with the Sun; and ſo you muſt do by every other Month, and by this Means the true Time of the Natural Day will be known more exactly, by keeping the Clock ſet to the Sun the Firſt Day of every Month, than can be done by thoſe who are ſet to go agreeable to Mr. *Flamſted*'s Table, which makes the Clock agree with the Sun but Four times in a Year, whereas, Gentlemen, I find, are better pleaſed to keep their well-adjuſted Pendulums as near to the Time given by the Sun as poſſible, which is to be done by new ſetting it the Firſt Day of every Month, which will be but the ſame Trouble as that of new ſetting the Day of the Month will be, which muſt be done if the Clock be kept well, in order in all its Motions.

But it ought to be noted that in the Work of adjuſting a Clock truly, and in keeping it after 'tis adjuſted as near to the Sun as in the Uſe of the Second Table is preſcribed, there ought great Care to be taken that the Clock-weight go not quite down, and ſo make it ſtand ſtill, which often happens, by forgetting to wind it up in due Time. Now this may be prevented, by fixing in the uppermoſt Part of the Trunk of the Caſe a ſmall Larrum, which the Weight, after 7 Days going, ſhall unlock by Means of a String or ſmall Chain, which is better fixt to the Side of the Weight with a Screw, and reaching up to the Triker, by which the Larum, by the going down of the Weight, muſt be unlock'd, which by its ringing down will give ſufficient Notice that 'tis time to wind the Clock up.

And here I think fit to add one Caution to thoſe that deſire to adjuſt their Clocks very nicely; and that is, that among Dials they make uſe only of the Horizontal or Braſs Dials, which are fixt on Poſts, for no other can poſſibly give the Time ſo near the Truth; neither on ſuch Dials ſhould they make uſe of above One certain Hour; and the nearer Noon that is the better; for 'tis a difficult Thing, even for the Beſt Maſters in this Art, to draw a Dial ſo true as to contain an equal Time between all its Hours; which though in other Caſes it be not very material, yet in this of adjuſting a Clock it may cauſe a conſiderable Error: Beſides, few Dials are fitted truly to the Latitudes in which they ſtand; and if we could be certain that all were right, as to theſe Particulars, yet no Humane Art can prevent the Sun's Refractions; which as they make his Body appear much bigger when near the Horizon, ſo they make it for a good Part of the Day to ſhew to us higher than really it is, and that muſt cauſe it to give a falſe Shadow on the trueſt Dial; ſo that theſe Particu-

lars

The Second Table of Equations, ſhewing how much a well-adjuſted Clock will gain or loſe in every Months Time, if ſet right to the Sun on the Firſt Day.

Mo.	Jan.		Feb.		Mar.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0 :	24	0	0	0	17	0	17	0	3	0 :	11	0 :	7	0	9	0	20	0	14	0 :	9	0 :	28
3	0 :	48	0	1	0	34	0	33	0	5	0 :	22	0 :	14	0	18	0	40	0	28	0 :	19	0 :	56
4	1 :	11	0	3	0	52	0	49	0	6	0 :	34	0 :	21	0	37	1	1	0	41	0 :	30	1 :	24
5	1 :	34	0	6	1	0	0	24	0	6	0 :	46	0 :	27	0	48	1	22	3	54	0 :	41	1 :	52
6	1 :	56	0	10	1	18	0	39	0	6	0 :	58	0 :	33	1	0	1	43	1	7	0 :	53	2 :	20
7	2 :	18	0	15	1	36	0	53	0	5	1 :	11	0 :	39	1	13	2	4	1	20	1 :	6	2 :	49
8	2 :	39	0	21	1	54	1	7	0	3	1 :	24	0 :	44	1	26	2	26	1	33	1 :	20	3 :	18
9	2 ,	50	0	27	2	12	1	21	0 :	0	1 :	37	0 :	49	1	40	2	48	1	44	1 :	35	3 :	47
10	3 :	10	0	34	2	30	1	35	0 :	3	1 :	50	0 :	53	1	54	3	10	1	54	1 :	41	4 :	16
11	3 :	30	0	42	2	48	1	48	0 :	7	2 :	3	0 :	57	2	9	3	31	2	3	1 :	58	4 :	45
12	3 :	49	0	50	3	6	2	1	0 :	17	2 :	16	1 :	0	2	24	3	52	2	11	2 :	15	5 :	15
13	4 :	7	0	59	3	24	2	13	0 :	15	2 :	29	1 :	3	2	40	4	12	2	18	2 :	33	5 :	45
14	4 :	24	1	8	3	43	2	25	0 :	20	2 :	42	1 :	5	2	56	4	32	2	25	2 :	52	6 :	15
15	4 :	40	1	18	4	2	2	36	0 :	25	2 :	55	1 :	6	3	12	4	52	2	31	3 :	12	6 :	45
16	4 :	55	1	28	4	21	2	47	0 :	30	3 :	8	1 :	6	3	29	5	12	2	37	3 :	33	7 :	15
17	5 :	9	1	39	4	51	2	57	0 :	36	3 :	20	1 :	5	3	46	5	32	2	42	3 :	55	7 :	45
18	5 :	22	1	51	5	11	3	7	0 :	42	3 :	32	1 :	3	4	3	5	52	2	46	4 :	18	8 :	15
19	5 :	34	2	4	5	31	3	17	0 :	48	3 :	41	1 :	0	4	21	6	12	2	49	4 :	42	8 :	45
20	5 :	45	2	17	5	51	3	27	0 :	55	3 :	52	0 :	56	4	39	6	31	2	52	5 :	6	9 :	15
21	5 :	56	2	30	6	10	3	37	1 :	2	4 :	3	0 :	52	4	58	6	50	2	54	5 :	31	9 :	45
22	6 :	6	2	44	6	19	3	46	1 :	10	4 :	14	0 :	48	5	17	7	9	2	55	5 :	56	10 :	15
23	6 :	15	2	58	6	38	3	55	1 :	18	4 :	25	0 :	40	5	36	7	28	2	55	5 :	11	10 :	45
24	6 :	23	3	13	6	57	4	3	1 :	27	4 :	35	0 :	55	5	55	7	47	2	54	6 :	37	11 :	14
25	6 :	30	3	28	7	16	4	10	1 :	36	4 :	45	0 :	30	6	14	8	5	2	52	7 :	3	11 :	43
26	6 :	36	3	43	7	35	4	17	1 :	46	4 :	55	0 :	25	6	34	8	22	2	49	7 :	30	12 :	11
27	6 :	41	3	58	7	54	4	23	1 :	56	6 :	5	0 :	20	6	54	8	39	2	45	7 :	57	12 :	38
28	6 :	45	4	14	8	13	4	29	2 :	7	6 :	15	0 :	14	7	14	8	55	2	40	8 :	24	13 :	5
29	6 :	48	4	31	8	32	4	34	2 :	18	6 :	34	0 :	7	7	34	9	11	2	34	8 :	52	13 :	31
30	6 :	50			8	51	4	38	2 :	29	6 :	43	0 :	0	7	54	9	27	2	28	9 :	20	13 :	56
31	6 :	51			9	9			2 :	40					8	14			2	20			14 :	21
	gain		loſe.		loſe.		loſe.		gain.		gain.		gain.		loſe.		loſe.		loſe.		gain.		gain.	
	6	51	4	14	9	9	4	38	2	40	6	43	0	1	8	14	9	27	2	20	9	20	14	21

If you ſet a well-adjuſted Pendulum right to the Sun on the 1ſt Day of every Month, this ſhews how much he will be faſter or ſlower than the Sun on any of the following Day of the ſame Month, the gaining or loſing being noted by Points between the Figures, or by the Want of them; for where you find Points between the Figures, the Clock will gain, or be ſo much too faſt each Day; on the contrary, where you find no Points between the Figures, there it will loſe or go ſo much too ſlow, the Numbers at the bottom of each Month ſhew how much you muſt ſet the Clock back, or put it forward the 1ſt Day of the next Month to bring it right with the Sun, if you cannot ſet it by the Sun itſelf; if it have gained, ſet it back ſo much; if it hath loſt, ſet it ſo much forward, as the Book directs.

lars conſidered together, 'tis plain that there can be no true Account taken of the Time till near Noon, or 12 a Clock; and he that watches for that Moment need not matter either the Falſeneſs of the Dial, wrong Latitudes, or Refractions; becauſe upon the Meridian let the Sun be either higher or lower, yet it ſtill gives you the true South Point, or 12 a Clock.

But in regard 'tis ſo very hard to diſtinguiſh to a Minute by the Shadow of the beſt Dial, ſmall ones not admitting of Minute Diviſions, and in large ones the Hazineſs or Faintneſs of the Shadow renders a Minute difficult to be diſcerned exactly, 'twill therefore be better if inſtead of a Dial you make uſe of the following Device, which I call a Meridian Cranny: Take then Two plain and flat Plates of Braſs, or Two Wooden Boards, about Six or Eight Inches ſquare, join them ſo cloſe as that an old Groat or a thin Six-pence at the moſt may but paſs between them, let them be fixed ſo as that the Chink or Cranuy that is between them may reſpect as near as may be the Meridian or true South Point, this will plainly give you the Time to the Tenth Part of a Minute, and leſs, if you are careful to watch for the very firſt Beam of Light that by the Sun's coming to the South Point ſhall be darted through it, which may be perceived in a Moment by the Help of a Piece of Paper or Parchment made Black with Ink, and placed before the Cranny to receive the Light when it firſt comes through; by this Means then the true Time of the Sun's coming to the South Point or Meridian may be more exactly obtained than can be done by the common Shadow of the beſt and trueſt Dial.

But it would be better for common Uſe if one had a large Dial made with a double Cock, that is, with Two Cocks of the ſame Size fix'd together, ſo that between them there may be left ſuch a Cranny as was before deſcribed; which may be done if the Fore and Afternoon Hour-lines are drawn from Two Centres, as is uſual in all large Dials; or in want of ſuch a Dial with a double Cock, a thick Plate of Braſs may be fitted to clap to the Side of the Cock of a large Dial, already made in ſuch a manner that a ſmall Cranny may be left between them for the Beam of the Sun to paſs through, when on any Day you would make your Meridian or 12 a Clock Obſervation: And here note, that when you do this you muſt have ready a good Pocket-Watch, that ſhews the Minutes; the Minute-Hand of which Watch muſt be ſet exactly to the Figure of 60 on the Minute Circle, when the Beam of the Sun firſt appears through the Cranny before-mentioned, and then go to your Pendulum Clock, and obſerve how much 'tis different from the Watch, for that will be the Time it hath either loſt or got ſince the Time it was laſt ſet true to the Sun by the help of ſuch a Meridian Cranny.

But now, altho' the true Time of the Sun's coming to the South, or 12 a Clock Point, may by this Means be obtained the neareſt, yet you will ſtill find the Work of adjuſting a Clock thereby to be ſomewhat difficult; I mean, to adjuſt it ſo preciſely that it ſhall agree exactly with an Equation-Table; and this hath made ſome to cenſure all Equation-Tables as falſe, becauſe they could not bring their Clocks to be juſt ſo much too ſlow or too faſt for the Sun as their Table did expreſs; which Complaint ſome have made concerning Mr. *Flamſted*'s Table, tho' others have confidently affirmed they have made their Clock go exactly with it, which perhaps may be as true as that of one who did affirm that a Clock which ſtood at King *Charles*'s Cloſet Door had gone exactly with the Sun for above a Twelvemonth, which is utterly impoſſible, as every one knows who underſtands the Nature of Days; but yet this Man at that time was the Keeper of the King's Clocks, and ſhould have known better.

Now that I may do Right to Truth, I affirm that tho' 'tis poſſible no Table of Equation may in every Part be nicely true for our Want of a moſt exact Hypotheſis of the Sun's Motion, yet the Errors cannot be ſo much as ſome Men would ſuppoſe, becauſe they cannot bring their Clocks to agree exactly with any Table of Equation; the Reaſon of which may be from their not taking that due Care in adjuſting their Clocks as ought to be done; 'tis probable indeed that the moſt exact Table yet made of this Kind may have ſome Errors for Want of an exact Knowledge of the Celeſtial Motions in thoſe who have contrived the Rules for Calculation, there being different Opinions among Men in that Matter, no Man having been among the Celeſtial Orbs to obſerve their Nature to a Nicety; and therefore one has contrived one Hypotheſis of the Celeſtial Motions, and another another, but yet they do all come ſo near the Truth in the Matter of the Equation of the Length of Narural Days, that we may truly ſay, as ſome do in many Caſes, *'tis there, or thereabouts*; that is, 'tis ſo near the Truth, that we may be certain that by the Help of ſuch a Table a Man may adjuſt a Clock much more exactly than he can do without ſuch a Help, it being impoſſible to adjuſt a Clock by the Snn, as before was ſhewed, if he underſtands nothing of the Inequality of Natural Days, as 'tis expreſs'd in my Firſt Table, which is as exact as any extant, tho' perhaps no more exact to a Tittle than any other Table is; for there muſt be Grains of Allowance given in Matters of Difficulty; and no Man that underſtands himſelf will dare to pretend to an infallible Certainty in Things ſo much above him as thoſe are, about which Aſtronomers are converſant, all our Knowledge in Things of this Nature being derived from Obſervations made by Inſtruments, which we know is difficult to be exactly done; ſo that if Ten Men ſhould attempt at the ſame Time to find out for Example the Sun's true Declination, (*the chief Ground-work on which the Equations are built*,) perhaps they would differ as to their exact Accounts thereof: Now, we know, if the Premiſes are never ſo little falſe, the Concluſions drawn from thence can never be exactly and critically true.

Therefore, granting the Poſſibility of ſome inconſiderable Error in the Tables of Equation, yet ſtill we are ſure of this, That they come very near the Truth, and the Work of adjuſting a Clock is thereby made an Hundred times more eaſie than it would be to do it without a Table. Thus we ſee that the moſt learned in Aſtronomy do agree all of them as to the main Thing, namely, That ſome Days in Four Parts of the Year are 24 Hours long, and that there is a Difference in the Length of all the other Days, and their Tables made by them do all agree as to the Parts of the Year in which theſe Differences happen, according as in my Firſt Table is expreſs'd, as it is now corrected, for Art is to be corrected always by Obſervation; they alſo accord very nearly as to the Quantity of Time that any Natural Day is longer or ſhorter than the 24 Hours Days; and therefore we may very well reſt ſatisfied that there are no very material Errors in theſe Tables; and perhaps could we demonſtrate any Table of Equations to be really exact to a Tittle, yet this Work of adjuſting a Clock truly would not be found much more eaſie to be done than it is now; for much of this depends not only upon the right underſtanding which Way to perform the Work in the beſt manner, but on the conſtant Temper alſo of the Air, as will hereafter appear.

But, to the end that we may not be in the dark, as to the true Nature of this Difficulty, I affirm that it chiefly proceeds from the exceeding Niceneſs of rectifying the Bob exactly, when you have already brought the Clock to go pretty near the true Time; as ſuppoſe, for Example, that a *Royal Pendulum* were ſo well rectified, that being kept going the whole Year round it ſhould be juſt at the ſame Day Twelvemonth but 6 Minutes 5 Seconds too ſlow for the Sun, which ſome perhaps will account a great Matter; now this turn'd all into Seconds makes juſt 365, and by Conſequence the Clock has gone each Day but a Second of Time too ſlow.

Now by the Table of Pendulums following we find that a Royal Pendulum, 41 Inches long, each Blow of which is a Second of Time, ſtrikes juſt 3600 Blows in an Hour, if ſcrew'd up an Inch ſhorter, which is faſter in a

Day near 1080 Seconds. Now if an Inch ſhorter makes a Pendulum go near 1080 Seconds in a Day faſter, 'twill then require the Bob to be ſcrewed up but the Thouſand and Eightieth Part of an Inch to make it go in a Day but One Second faſter, or ſo much as the Clock is ſaid to have loſt; which is ſo very ſmall a Matter, that no Man living can by gueſs hit it exactly; the leaſt Motion a Man at a venture can give it may perhaps make it go Ten Times as much too faſt as it before went too ſlow.

Now to the end that this may, if poſſible, be done by ſome more certain Rule and Method than any yet commonly known, I will here make bold to propoſe a Way by which this may be performed more exactly than heretofore, and by which you may make a near Eſtimation how much a Royal Pendulum that ſtrikes Seconds *(for this Sort only is here intended)* ought to be made ſhorter or longer, to go faſter or ſlower a Second in a Day; and the ſame Rule by which you know how to alter it One Second, will direct you how to alter it 2 or 3, or more, if Occaſion require it,

By the forementioned Table of Pendulums we find that a 41 Inch Pendulum goes 45 Blows (which are all nearly Seconds) in an Hour faſter, if ſcrewed up an Inch higher; and being let down an Inch longer, it then goes 34 Blows ſlower, that is, ſtrikes ſo many Blows leſs in an Hour. Now if between theſe 2 Numbers we take a mean one, which is 44, 'twill be ſuitable to the Lengths near 41 Inches, for ſo many Blows will a Pendulum 39 and an half ſtrike more than one of 41 Inches and an half long: Now 44 difference in an Hour makes in a Day 1056, divide this Number 1056 by the Number of Turns which the Screw of your Pendulum makes in an Inch, and the the Quotient ſhall be the Number, into which the Nut of that Screw muſt be divided; now one of theſe Diviſions turned about ſhall alter the Motion of that Pendulum a Second in a Day.

But to avoid the Trouble of thus dividing, I have here added a Table, by which, knowing the Turns your Screw makes in an Inch, you may, by Inſpection only, know how to divide the Nut that belongs to it; the Table reaches from 15 Threads or Turns of the Screw in an Inch to 40, within which Numbers, I ſuppoſe, all Screws will be comprehended that belong to Pendulums that ſtrike Seconds.

The Table for dividing the Nut of a Pendulum Screw.

Turns.	Diviſions.
15	70
16	66
17	62
18	58
19	55
20	52
21	50
22	48
23	45
24	44
25	42
26	40
27	39
28	37
29	36
30	35
31	34
32	33
33	32
34	31
35	30
36	29
37	28
38	27
39	26
40	25

The Uſes of the Table for dividing the Nut of a Pendulum Screw.

Find out how many Threads or Turns of your Screw are contained in an Inch, by applying the Inch-Diviſion of a Rule thereunto, which Number of Turns ſeek out among the firſt Row of Figures on the Left Hand, and againſt it, in the ſecond Row, you have the Number that the Nut muſt be divided into that belongs to that Screw: Now the Nut, turn'd about but One of theſe Diviſions, will alter the Clock's Motion a Second in a Day; ſo that let the Screw be finer or courſer, yet by this Table you may readily know into how many Diviſions its Nut muſt be divided. Note, that if the Clock has got or loſt in a Day above One Second, then you muſt turn the Nut about ſo many Diviſions; as if it have loſt in 60 Days 4 Minutes, which is 4 Seconds in a Day, turn it then upwards 4 Diviſions, and that will make it go 4 Seconds in a Day faſter, or ſo much Time as it had gone too ſlow: And the like muſt be done for any other Number loſt or got.

Now though this Rule be Ten times more exact than any yet known, yet for all that it may be yet found difficult to make a Clock go exact, eſpecially for a long Time together; for though a *Royal Pendulum* be the moſt Excellent Contrivance in the World for an exact keeping of *Time*, yet the different Degrees of *Rarity* and *Denſity* in the *Air*, from Heat and Cold, does ſometimes alter the Nature of the *Pendulums Motion*, a *thick Air* not ſuffering it to *vibrate* ſo freely, nor ſo far, as a *thin Air* does; hot and cold *Air*, by Dilating or Contracting the Metal, of which a Clock is made, may alſo cauſe its Motion to vary; the *Motion* of the *Pendulum* may alſo be ſomewhat altered by the *Oil* growing thicker, or more clammy, with which the *Peuets* muſt be moiſtned, for when a Clock is clean, and the *Oil* thin, and free from Foulneſs and Duſt, the *Pendulum* plays differently from what it does when the Clock is foul, and the *Peuets* dry and dirty: But here you are to note, That notwithſtanding the *Royal Pendulum* is ſubject to be altered ſomewhat in its *Motion* by the aforeſaid Cauſes, yet 'tis nothing in Compariſon to what happens in the common Crown-wheel *Pendulums*, which ſwing out much farther; for theſe are apt to be varied Ten times more than the other, which ſtill makes very much for the Excellence of the *Royal Pendulum* above others.

Since then the *Air*, and *Oil*, and *Duſt*, are apt to cauſe the beſt Clock to go leſs certain than it otherwiſe would, by altering the Compaſs of the *Pendulum*, I have thought fit to propoſe a Way by which it may be known when any thing conſiderable of this Nature happens, and that is thus, ſcrew or faſten to the Back of the Caſe a *Braſs Plate*, with Two ſliding *Indexes* fitted to it, that may be ſet exactly to the Compaſs which your *Pendulum* fetches, and by that you may perceive whether your *Pendulum* alters in its Compaſs, for ſhould it do ſo in the Time of your adjuſting of it, you will not *rectifie* it well; and if nothing of this happens till it be brought to go true, yet if the Compaſs of your *Pendulum* does afterwards differ, you will certainly find it not to keep the ſame Time it did when firſt adjuſted, and the beſt Clocks that are will ſometimes be ſubject to theſe unavoidable Accidents.

But altho' thoſe little Irregularities in the Motion of a good *Pendulum* may ſometimes happen, and prove ſome hindrance to the Exactneſs of its Motion, yet when you come to know how much it varies from the Truth, you may ſoon correct it by the foregoing Rules, if you ſee Occaſion. Indeed if it vary from the *Influence* of the *Air*, that Aptneſs to go falſe will continue no longer than till the Temper of the *Air* returns to its former State, and then the Clock will return to its old Pitch of *Motion*; but if it happen through *Foulneſs*, (which may be gueſt at by its having gone true a long time before,) then 'twill continue to go *Irregular* till the Clock be made clean, new oil'd, aud put in order: But when all is ſaid that can be ſaid on this Matter, if the Clock be a well-made Piece of Work, all theſe Alterations in the *Motions* will be ſo inconſiderable, as not to be worth the noting, if you obſerve conſtantly to ſet it once a Month according to the *Second Table*; but for *baſe* and *ill Work* no Art of Man can make that go exactly and well One Quarter of the Time that the other will, which was made by a good Workman.

From what then has been ſpoken hitherto concerning the *Royal Pendulum*, we may gather that the ſame Exactneſs of keeping Time is not to be expected in ſhort or *Crown-wheel Pendulums.* Indeed if ſuch are *good Work*, they may be made to go very well, but yet not ſo exactly as the *Royal Pendulum*; for the ſhorter the *Pendulum* is, the more difficult it is to adjuſt it exactly: And when the adjuſting Part is done never ſo true, yet the Uncertainty that this kind is ſubject to in the Compaſs it fetches will not ſuffer it to keep ſo equal a Time as the *Royal Pendulum*; the different *Temper* of the *Weather* will alter it very conſiderably, if compared with the other; and 'twill alſo be ſooner out of Order in the going than a *Royal Pendulum* from the *Foulneſs* and *Thickneſs* of the *Oil* that the *Peuets* are moiſtned with, occaſioned by the Duſt that gets into the Caſes, which makes the *Pendulum* fetch a far leſs Compaſs than when 'tis clean, to which Foulneſs the ill Invention of Braſs Caps do much contribute, who let in much Duſt through the thin Silk, with which the Cap is lined.

The beſt and eaſieſt Way to adjuſt ſuch a Clock as this is by a *Royal Pendulum*, already *Rectified*, to ſerve for a *Standard* to *adjuſt* other Clocks by; for when by that you have brought a ſhort *Crown-wheel Pendulum* pretty near to the *Truth*, take exact Notice how much it differs from it in either One or Two Days, as you pleaſe; then give the *Bob* juſt a whole Turn about upward, if it go too ſlow, or downward, if it go too faſt, and ſee how much that *Turn* will make it differ from the *Standard* more than what it did before in a Day or Two Days time. Now knowing how much Time in a *Day* a *Turn* of the *Bob* will alter, you may ſoon bring it to keep *true Time*, by turning it ſo many *Turns*, or *Parts* of a *Turn-about*, as ſhall anſwer the *Time* it has thus gone too faſt, or too ſlow.

As for thoſe *Pocket-Watches* which are now ſo *improperly* called *Pendulums*, there is leſs to be expected from *them* than from a *Crown-wheel Pendulum*; for though this *delicate Invention* does ſtrangely *Rectifie* the *Motion* of the *Ballance*, yet muſt it not compare with either of the others as to the Truth of *going*; for 'tis the hardeſt *thing* in the World to make a *Watch* keep the ſame *Time*, when laid on what *Part* or *Side* ſoever you will be pleas'd to turn it, which, rightly conſidered, may reaſonably obtain for them ſome Grains of Allowance: All that I ſhall add more is, that if you know but nearly how much the *turning* of each *Diviſion* on the *Juſtning Plate* will make it go either faſter or ſlower, you may then at any time with greater Certainty adjuſt it to a *Standard Pendulum*; and this any one may attain to with but the Trouble of a little Obſervation; for if the Watch, for Example, have gone too ſlow Two Minutes in a Day, turn the *Juſtning Plate* about One Diviſion faſter, and if that Diviſion make it go Four Minutes too faſt, inſtead of the

Two, which before it went too ſlow, then conclude that that Diviſion has altered it in a Day Six Minutes; and by Conſequence if you turn it *Two Thirds* back it will make the Watch go right as it ought to do.

I ſhall only add One more *Note* concerning *Spring Clocks*, or thoſe that go with *Crown-wheel Pendulums*; and that is, that although as yet they have not been capable of keeping ſo exact a Time as the *Royal Pendulum*, yet if the Pendulum of a Spring-Clock inſtead of playing upon an Edge, as they now generally do, were hung upon a fit Spring, about Three Inches long, and that Spring were ſo filled according to Rules of Art, as that in the Pendulum's Vibration it might bend proportionable to a *Cycloid*, its Centre of Motion then would ſtill ſhorten as the Way of its *Vibration* grows longer; and by Conſequence the farther the Pendulum ſwings out, the quicker would its return be, and ſo all its *Vibrations*, whether in a wider or narrower Compaſs, would be performed in the ſame equal Time, and then its Motion would be much more ſteady than it is, and be nearly as exact as that of a *Royal Pendulum.*

The manner of Rightly Fixing, or Setting up Pendulums *to go well.*

THE Difficulty of ſetting up *Pendulum Clocks* rightly in ſuch Places where the help of the *Clockmaker* cannot be had, is the Reaſon that many Gentlemen who live far off from *London*, are as yet unfurniſhed with them; and it alſo too often happens, that *Clocks*, who at firſt have been ſet up well as to matter of going, have afterward by accident been miſplac'd or jumbl'd awry, and ſo are made to go falſe, or ſtand ſtill, and become uſeleſs meerly for want of Skill in the Owner to put them again to rights; in order therefore to enable all Perſons not only to ſet a Pendulum Clock up rightly, but alſo to reduce it again to rights, when by Accident it is miſplac'd, I have here made publick the following *Directions*.

Firſt, Let the Workman, by whoſe Hands the Clock is made, ſet him upright at home in his own Houſe, and there having made a through trial of his going, let him then ſtop the Pendulum, and when 'tis perfectly at reſt let him fix or drive into the Back of the Caſe a ſtrong Stud of Braſs or Iron, with the End turn'd a little up, which he muſt place ſo as that the Beak that turns up may ſtand exactly under the lower end of the Pendulum Rod, and this will ſufficiently direct you how to ſet him up in any other Place: For when the Clock is to be ſet up by him that Buys him, 'tis but placing the Caſe ſo that the End of the Pendulum Rod may hang juſt over the Beak of the Stud, and then he will ſtand upright as he did before in the Workman's Hands.

But in caſe this Proviſion be not made, then the Rule to do it by is this; ſet the Clock up in the Place 'tis to ſtand in, let the Pendulum and the Pulleys which uſually are fix'd to the Caſe be unfaſtned, hang on the Weights, and ſet the Pendulum a going, by making of it ſwing between the Sides of the Caſe; now if when it is thus ſet a going you find the Pendulum to beat equally, that is, if there be the ſame Diſtance of Time between all its Blows, which an attentive Ear will ſoon diſcover, then does the Clock ſtand well, and you muſt make it faſt to the Place it ſtands againſt: But if you find one Blow Beat in leſs Time than the other, then you muſt a little incline the Caſe to that Side by the Help of Two Wooden Wedges which the Pendulum plays to when he ſtrikes the ſhorteſt Blow, and then you will find him to Beat more equal; and when you have inclin'd the Caſe ſo much that you find exactly the ſame Diſtance of Time between the Blows or Vibrations, then the Clock ſtands right for going, and you are to fix him that he may ſtand firmly in that Poſture.

Now the Rule before given is general to all Pendulums, for they all muſt ſtand ſo that the Beats of the Pendulum may be equally diſtant as to length of Time, for otherwiſe if they ſtand awry, ſo that one Blow, or Vibration of the Pendulum, is ſtruck in leſs Time than the other, that Pendulum will be apt to ſtand ſtill; and therefore great Care ought to be taken that not only *Royal Pendulums*, but alſo *Spring Clocks*, be ſet up exactly upright in the Places that they are to ſtand in; and they never ſtand upright as they ſhould do, unleſs the Blows of the Pendulum Beat equally, as before was ſaid.

Note, That as a long Swing-Clock ought to ſtand ſo that the Pendulum Beats equally, ſo he muſt ſtand ſo that the Pendulum play free from the Back of the Caſe; for if it ſtand right, in this reſpect the Rod of the Pendulum will all the way up be parallel or equidiſtant from the back-part.

Moreover, take Care that the Clock be fix'd faſt and firm, that no Violence may juſtle him out of his Place; but if by Accident it ſhould ſo come to paſs, you muſt then ſet him again to rights by the Rule before given, from the exact Beating of the Pendulum.

A Table of Crown-Wheel'd Pendulums, ſhewing the Number of Beats made in an Hour, by any Length of Inches and Quarters, from One Inch to Twelve, the Bob about an Ounce in Weight.

Inches.	Beats.	Inches.	Beats.
1——	22946	7——	8672
1	20524	1	8524
2	18735	2	8381
3	17345	3	8242
2——	16225	8——	8107
1	15298	1	7989
2	18735	2	7870
3	13837	3	7764
3——	13248	9——	7653
1	12732	1	7544
2	12265	2	7448
3	11852	3	7249
4——	11473	10——	7256
1	11131	1	7167
2	10817	2	7081
3	10528	3	6998
5——	10262	11——	6919
1	10014	1	6842
2	9781	2	6767
3	9569	3	6694
6——	9368	12——	6623
1	9178	1	6565
2	9000	2	6497
3	8832	3	6431

The firſt Row of Figures are Inches, the ſecond are Quarters of Inches; the Figures againſt each of theſe are the Beats that a Pendulum of that Length makes in an Hour. For Example, A Pendulum of 2 Inches long beats 16225 Blows in an Hour; and 3 Inches and a half 12265; and One of 6 Inches 3 Quarters beats 8832; divide any of theſe Numbers by 60, and it ſhews you the Beats made in a Minute, multiply any of theſe by 24, and it ſhews you the Beats made in a Day.

A Table of Royal Pendulums, ſhewing what Beats any Length makes in an Hour from 12 *to* 60 *Inches, the Bob* 2 *Pound Weight or more.*

Inches.	Beats.	Inch.	Beats.
12	6651	39	3691
13	6393	40	3645
14	6161	41	3600
15	5955	42	3557
16	5765	43	3515
17	5591	44	3475
18	5433	45	3436
19	5288	46	3399
20	5154	47	3362
21	5030	48	3327
22	4915	49	3293
23	4807	50	3260
24	4706	51	3228
25	4610	52	3196
26	4522	53	3166
27	4437	54	3137
28	4356	55	3108
29	4281	56	3080
30	4209	57	3053
31	4141	58	3027
32	4075	59	3001
33	4013	60	2976
34	3953	61	2951
35	3897	62	2927
36	3843	63	2904
37	3790	64	2880
38	3793	65	2859

In this Table, the firſt Row of Figures, in each Column, are the Inches of the Pendulum's Length; the ſecond Row are the Beats that a Pendulum of that Length makes in an Hour. Thus One of 41 Inches long beats 3600 times, and One of 64 2880.

The Table of Royal Pendulums continued, from 3 Foot long to 30, for the Uſe of ſuch as make Church and Turret-Clocks.

Foot.	Beats.
3	3842
4	3327
5	2976
6	2716
7	2515
8	2353
9	2218
10	2104
11	2006
12	1912
13	1845
14	1778
15	1718
16	1664
17	1614
18	1568
19	1526
20	1488
21	1452
22	1429
23	1387
24	1353
25	1331
26	1305
27	1288
28	1257
29	1235
30	1215

In this Table the firſt Row of Figures are the Length in Feet of any Pendulum in large Work, the ſecond Row are the Beat that that Length makes in an Hour; as 10 Foot long beats 2104 times in an Hour, and a Pendulum of 20 Foot long beats in an Hour 1488 Blows.

The foregoing Tables I was in ſome meaſure neceſſitated to publiſh, in order to demonſtrate why heretofore it has been found ſo difficult to adjuſt a Clock to the Table of Equations. But, beſides this, I thought it might be of good Uſe to ſome, who, in contriving Numbers for new Clocks, or for old Clocks altered into Pendulums, are often at a Loſs what Length of Pendulum to fit their Number to. Perhaps my ſo doing may anger ſome, but the pleaſuring of more Men will countervail that Miſchief.

The Table of Crown-wheel'd Pendulums is calculated from a Standard of the ſame ſort, 6 Inches and a half long, that ſtrikes 9000 Blows in an Hour: And that of Royal Pendulums from One of 41 Inches, that ſtrikes Seconds, or 2600

Blows in an Hour. The Tables are as exact as poſſible as to their whole Numbers, and would always give you the Length, did not different Ways of making Clocks cauſe an Alteration, inſomuch that ſometimes a Pendulum that ſtrikes Seconds ſhall be above a quarter of an Inch longer than another ſhall; making ſometimes half an Inch, if the Wyre of the Pendulum is very large; for the Difference in the Bigneſs of the Rod of a long Pendulum will make a Difference in the Length; and if Two Rods ſhould be both of a Size, and ſwing a like Diſtance, yet ſome other Difference in the making may cauſe the Pendulums to be different Lengths, tho' they beat the ſame Number of Blows, and keep Time alike, as I once ſaw in Two Pendulums, deſigned to be about 40 Inches, or to ſtrike 4 Blows in 5 Seconds, where the One Pendulum was 2 Inches longer than the other, and yet they both went true.

THE BEST RULES FOR THE Ordering and Uſe Both of the Quickſilver and Spirit Weather-Glaſs.

SInce 'tis ſo eaſie to be furniſhed in *London* with both the Sorts of Weather-Glaſſes, I judge it needleſs, now, to give any Directions about their Making; only thus much I ſhall take Notice of, That the Goodneſs of a Baroſcope or Quickſilver Weather-Glaſs does conſiſt very much in the Largeneſs and Depth of the Ciſtern below, and the

Quantity of Quickſilver contained therein. Now, that you may know whether a Ciſtern be large enough, cauſe the Workman that makes it to fill the Tube about 3 Inches with Part of the *Mercury* deſigned for its Uſe; fill the Ciſtern with the beſt Part of the reſt that remains; and then clapping acroſs the Brims of the Ciſtern a Gage that ſhall have a Pin drove into it, reaching juſt down to the Surface of the *Mercury*, let the *Mercury*, which before filled the 3 Inches of the Tube, be put therein; and if you find it not to raiſe the *Mercury* in the Ciſtern above the Thickneſs of a Six-pence, then is the Ciſtern of a ſufficient Wideneſs.

A Ciſtern of about 2 Inches and a half Diameter generally is large enough for any Tube, that has not a Bore above a quarter of an Inch Diameter, which is as large as is needful; for if it be ſo large, as that when the Quickſilver in the Glaſs, by riſing and falling, do raiſe that in the Ciſtern too conſiderably, then you will not conſtantly have that Diſtance between the Surface of the ſtagnant *Mercury* below, and the numbred

Figures on the Regiſter Plates of the Weather-Glaſs; for if the Glaſs be a good Glaſs, meaſure that Diſtance when you will, and you will always find it juſt 28, 30 or 31 Inches from the Diviſions ſo numbred to the Superficies of the Quickſilver in the Ciſtern below.

Note likewiſe, That the End of the Tube ought to be emerſt at leaſt Three quarters of an Inch within the Ciſtern of Quickſilver, elſe the Air will be in danger of getting up into the Body of the Tube: For this reaſon there ought to be at leaſt 28 Inches and 3 quarters Diſtance between the Figure 28 on the Regiſter Plate, and the Bottom of the Ciſtern.

Now, in order to ſet the Weather-Glaſs up, let the Frame be firſt fixed faſt to the Place you deſign for it; which is done by firſt driving therein a Nail or Tenterhook, fitted for that Purpoſe, upon which the Frame is to be hung or ſuſpended, and, with a Screw, let the Bottom thereof be firmly faſtned to the Place, or, in want of a Screw, by ſomewhat elſe that may perform the Work well.

Then make the Inſide of the Glaſs Tube very clean and dry, by Means of a bright and clean Piece of Wyre, made red hot at the end in a Fire, and turned down for about half an Inch, like the Eye of a Needle, through which draw a long ſlip of fine ſoft Lawn Paper, which I find beſt for this purpoſe, becauſe 'tis not apt to leave any Lint behind it, as Linen Rags will; which Lint will always cauſe a ſmall Bleb of Air to remain round it, ſo that in ſpite of all your Care and Pains you ſhall never obtain a perfect fine Cilender of *Mercury*.

With this Paper, in the Eye of the Wyre, let the Bore of the Tube be well cleanſed, by drawing of it to and fro, from one End to the other, till you are ſure that you have not miſs'd any Part thereof: And if you find, when you have drawn it out, that the Paper be any whit ſoiled, put in a freſh Piece, and after that another, till you find the Paper come out as clean as it went in; for ſhould any Foulneſs or Moiſture be left behind the *Mercury* will not play freely up and down.

When you have cleanſed the Tuble very well, then prepare and make the *Mercury* fit to fill it with, which you are to do in the manner following.

Take an Earthen Baſon or Diſh, and put therein half a Sheet of clean white Paper; then put the whole Quantity of *Mercury* which the Maker of the Baroſcope has fitted thereunto, and having put it into a clean Linen Cloth, ſtrain out gently ſo much of it as you judge will fill the Bore of the Tube, and no more; for ſhould you twiſt and wring the Cloth the Quickſilver is in, to ſtrain it all through, you will, in ſo doing, find much Lint fall off from it, and foul the Surface of the *Mercury* ſtrain'd out, ſo that you cannot fill the Tube with it without conveying ſome of the Lint along with it, which will ſpoil the perfect Smoothneſs of the Mercurial Cylender within the Glaſs.

When you have purely ſtrained out about One half of the Quickſilver, take the Tube, and reſt the cloſed End in ſome large Wooden or Earthen Veſſel, to ſave the *Mercury*, ſhould any ſpill in the filling; then graſp the open end of it between the Root of the Thumb and Fore-finger, ſomewhat low, that the Hollowneſs between may ſerve inſtead of a Tunnel; then fill the Tube with the pure clean-ſtrain'd Quickſilver, by taking of it up with the clean Bowl-end of a Tobacco-Pipe, or by putting of it into the Ciſtern-Glaſs, firſt wiped clean, and ſo pouring of it in till it be full, within a quarter of an Inch of the Top of the Tube.

Then, to cleanſe it from Air and Wind-Blebs, ſtop the End with your Finger, and raiſing the other End up, ſomewhat above a Level, let the Air, included in the empty Space, at the open End, riſe up very gently towards the Top or ſealed End, and this will take into it ſelf all the other Blebs of Wind that lye in its Way; and when this Bubble of Air is riſen up quite to the End of the Tube, let it return again, by depreſſing a little that End which before was uppermoſt, turning the Tube alſo at the ſame time, that the Bubble may take in its Way all the Blebs of Wind that may yet remain on the other Sides of the Glaſs; and thus by turning the Tube a little and making the Bubble paſs and repaſs from one End to the other, the Cylender of Quickſilver will be at laſt cleanſed from all thoſe little Blebs of Wind that appeared by the Sides of the Glaſs, any of which, ſhould they remain in, would in Time work themſelves up into the Head of the Tube, and be very injurious to the Quickſilvers true Motion.

But if, as I noted before, the leaſt Moiſture or Lint be left in the Tube, the greateſt Care and Skill that can be uſed will not be able ſo perfectly to cleanſe it from Air, as not to leave the leaſt Speck remaining: In which Caſe there is no Remedy but to empty the Tube, and cleanſe it anew, according to the Method before preſcribed. *Note*, When the Tube is perfectly cleanſed from Air, then turn the open End up, and fill it quite full with Quickſilver.

Then wipe the Ciſtern very clean, and ſet it in its Place, in the Ciſtern-Box, then put therein all the remaining Part of your *Mercury*, which you need not take Care to ſtrain, for Duſt or Foulneſs in the Ciſtern ſignifies little; then take the Glaſs Tube, filled as before was taught, and ſtopping the End of it with your Finger, invert it ſo that you may immerge or put the End, ſtopt with your Finger, the more eaſily into the Ciſtern *Mercury*, which ought to be done ſo that both Glaſs and Finger may touch the Ciſtern Bottom at the ſame time, keeping the Tube in the mean while as near an upright as you can; then of a ſudden take away the Finger you ſtopt it with, and as ſuddenly, at the very ſame Inſtant of Time, raiſe the Tube juſt upright, the which, if you perform nimbly and well, will be done before the *Mercury* in the Tube is all ſunk down to its loweſt Station, and ſo the Tube will be put up well, without any Admittance of outward Air.

But in Caſe any Air ſhould get into the Tube, in your attempting to ſet it up in its Place, as ſometimes happens, then you muſt take it down again, by getting your Finger under the open End, to ſtop it before you lift it out of the *Mercury* in the Ciſtern, and ſo repurge it of the Air got in, according as you were taught in the foregoing Method, and then try again to ſet it up well; and if you ſhould miſs this ſecond time, then try a third, for Experience will at-length make you perfect.

When the Tube is put up, obſerve whether it ſtand well in the Ciſtern; for ſome Ciſterns are ſo ill-plac'd, that the Tube, by reaſon of its being ſet too near the Side, cannot be well ſurrounded by the Ciſtern *Mercury*, by which Means the Air will be apt to inſinuate itſelf, and get up into the Tube, and ſpoil the true Motion.

If the Glaſs be already adjuſted to your Hand by the Workman that made it, you have then no more to do but to put into the Ciſtern all the *Mercury* that remains when the Tube is filled; but in caſe the Glaſs be not already adjuſted, or that ſome Part of the Quickſilver ſhould be ſpilled or loſt, you muſt then proceed to adjuſt it according as the Rules of Art require; which is done thus, Take a ſmall ſtreight Rod of Wood, of the juſt length of 28 Inches, this is generally called, *An Adjuſting Gage*, put one End of it into the Ciſtern, and raiſe the other up till it touch the Diviſion on the Regiſter-Plate, numbred with the Figure 28; then obſerve whether the Quickſilver in the Ciſtern does touch the other End; if it does not, you muſt put in more *Mercury* till it does; but if the *Mercury* be already above the lower End of the Gage, then you muſt, with the clean Bowl-end of a Tobacco-Pipe take out ſo much of the Quickſilver as that that in the Ciſtern may but juſt touch the End of the Gage, and then is the Glaſs compleatly and well adjuſted.

In caſe you have Occaſion to remove a Baroſcope, or Quickſilver Weather-Glaſs, out of one Room into another, you need only looſen the Frame, and take it from the Place to which it is fixt, and ſo, upright, in the ſame Poſture it ſtood in, let it be carefully conveyed by Hand ſo gently, and with a careful Step, that the Quickſilver may not ſurge over the Sides of the Ciſtern, another Man, in the mean time, making all Things fit to ſet it up in its new Place, according to the Directions before given for ſetting of a Weather-Glaſs up.

But here note, That if the Baroſcope be to be removed from one Houſe to another, it muſt be quite taken down: In doing which obſerve, Firſt, To incline the Tube Head ſo low as the Tube ſtands in the Ciſtern, that the Quickſilver may riſe up quite to the top, then lift it out of the Ciſtern, and let the *Mercury* run out; for ſhould you lift the Tube out in the Poſture it ſtands in, the *Mercury*, by the Force of the Air's Preſſing in at the open End, would fly up to the top with ſuch Violence as to endanger the breaking off of the top of the Glaſs. *Note*, That if the Glaſs Tube be not well purged of Air, the Quickſilver will, by long ſtanding, be apt to move contrary to the true Nature of a Baroſcope, by reaſon that the Air which has been left in the Tube has by degrees got up into the Head or empty Space of it, where being expanded by any accidental Heat of Air, it occaſions the *Mercury* to ſink, though the Weight and Preſſure of the Air be no ways altered; this is obſerved by Dr. *Beale*, *Phil. Tranſ.* Numb. 9. p. 157. That a Baroſcope aſcended higher in the cold Mornings and Evenings than at Mid-day; which doubtleſs proceeded from the aforeſaid Cauſe; for if you leave, for tryal-ſake, a little Bubble of Air in the Head of the Glaſs when you ſet it up, you will find the ſame Defect, as Dr. *Beale* has obſerv'd.

Wherefore 'tis neceſſary if you are doubtful of the like, to Rectifie your Weather-Glaſs when it has been ſet up about a Twelvemonth, which is done by taking of the Tube down, and repurging of it of Air, as you were taught in firſt ſetting of it up: But that you may not be put to more trouble than needs, you ought to be firſt certain that your Weather-Glaſs does want Rectifying, which you may know thus; Let the Head of the Tube as it ſtands in the Ciſtern be ſtoop'd down ſo low till the Mercury riſe quite to the Head, and if you perceive a Bubble of Wind at the top above the Quickſilver, that is the certain ſign of its wanting to be new Rectified; clap then your Finger under the open End in the Ciſtern, and take it out and purge out the Air, as before was directed, at its firſt ſetting up.

Of the Uſes of the Baroſcope, or Quickſilver Weather-Glaſs.

AND here it may not be amiſs in the firſt Place to ſhew you my Opinion concerning the Reaſons of that different Weight of Air which is now generally believ'd, (and that with good Reaſon too,) to be the Cauſe of the Quickſilver's riſing againſt fair, and falling againſt foul Weather: Now the Reaſons or Cauſes of this I take to be principally Two, the one is the dilating and contracting of the Air, and the other is the Air's being empty of watery Vapours, and ſometimes filled with them.

That the Air is capable of Contraction and Expanſion is plainly apparent by its dilating with Heat, and contracting by Cold, in the Bolt-head of a Thermoſcope, or Water Weather-Glaſs.

Now if the Air be contracted into a leſs room, by what Cauſe it will, the Adjacent Air flows in to make good the Level of the *Atmoſphere*, and ſo by the Addition of more Air, the Cylender which buoys up the *Mercury* in the *Weather-Glaſs* becomes heavier, and by Conſequence makes the Quickſilver riſe; and though in Summer-time it may be thought that the Heat we feel ſhould rather Expand than Contract, yet in this we may be deceived; for though the Air be Hot juſt at the Earth by the Sun's Reflection, yet the upper Regions are ſtill as cold as ever; witneſs the *Snow* which continues all the Year round on the Tops of ſome very high Mountains, and ſo the Air may very well be accidentally contracted in the hotteſt Time of Summer, as well as in the coldeſt Winter, and be one Occaſion of the Air's being then as heavy in dry Weather as in the faireſt time of Winter.

And as the Air is made heavier by Contraction, ſo 'tis made lighter by Expanſion; for when its Body is rarified from what Cauſe ſoever, the Swelling thereof cauſes the higheſt Part to flow off, or, as I may ſay, run down on thoſe Parts of the *Atmoſphere* that are below it, by which means the *Cylender*, or Pillar of it that preſſes on any Places, becomes lighter, and ſo the *Mercury* in the *Baroſcope* is ſuffered to ſink down or deſcend.

And that the Air's being ſometimes full of watry Vapours, and ſometimes empty, is another and the chief Reaſon too of the *Quickſilver*'s riſing and falling, is manifeſt from this Principle in *Philoſophy*, That whatever riſes up and ſwims in any *Medium*, muſt Bulk for Bulk be lighter than the *Medium* by which it is ſuſtained: Hence it follows, that all kinds of watry Vapours muſt be lighter than the Air, elſe they could never riſe up therein, nor be ſuſpended there, till by another Principle in Nature they are made to deſcend in Rain or Snow. Now if Water thus rarified be ſpecifically lighter than Air, then 'tis plain, that when the Air is filled therewith it muſt become leſs weighty than it was before: As a Glaſs filled with half Water and half rectified Spirit of Wine, a much lighter ſubſtance, ſhall not weigh ſo much as when fill'd with all Water; ſo the Air is always lighteſt in wet Weather, because the Spaces above us are then full of Vapours, much lighter than the Air is, and by conſequence the Body of Air, and watry Particles mixt together, muſt weigh leſs than if the whole were only an unmixt and pure Air.

On the contrary, when the Air is dry, and free from being thus fill'd with watry Vapours, it muſt then be moſt heavy at ſuch times: Indeed we may perceive many large white and curled Clouds ſailing aloft over us; but theſe are only a Collection of ſome few Vapours in the very upper Region of the Air, the Spaces below being in the mean time very little, or not at all filled therewith; whereas in very wet Weather, when the Glaſs is low, and the Air very light, we ſee not only the upper Region full of compacted Vapours, but find alſo the whole *Atmoſphere* even down to the Surface of the Earth filled therewith, as is manifeſt by the Sweating of Stones, and other Tokens of the Air's extream Humidity; and by conſequence the fuller of light Matter the Spaces above us are, the leſs will the Weight be that preſſes downward; and for that

Reaſon the Glaſs in the wetteſt Weather always ſinks loweſt.

This being premiſed, I come to the more particular Uſes of the Glaſs; and firſt, you may perceive by what has been ſaid, That the Glaſs gives a very good Account of the Temper of the Air, as to its Moiſture or Drineſs, the Moiſture thereof, or its Fulneſs of watry Vapours, being always proportionable to the Lowneſs of the *Quickſilver*; and every Degree of Sinking is an Argument of the Air's being filled more and more with Moiſture; and the lower its Station, the more full of Moiſture the Air ſtill is; and you ſhall always obſerve, That the lower the *Quickſilver* deſcends, the more liſtleſs and out of order Mens Bodies are, becauſe the Air is then full of that which is diſagreeable to the Nature of Man, who was not made to live in a watry Element: And therefore the more watry the *Medium* is in which he lives, the more is his Nature diſturbed at it.

On the contrary, The higher the *Quickſilver* is, the drier ſtill is the Air; and by conſequence Mens Bodies are then found to be more briſk and lively, becauſe the *Medium* in which they live and move is free from what their Nature abhors; ſo that by the *Weather-Glaſs* may be known in great Part whether the Diſorder and Melancholy, or the Periodical Pains and Aches to which we are ſometimes unavoidably ſubject, is really occaſioned by a new bodily Diſtemper or not; for this happening when the *Quickſilver* is low, may be judg'd to be occaſioned rather by the Air, and by conſequence will go off naturally of itſelf when the *Quickſilver* riſes; a too moiſt Air has ſtranger Effects on Mens Bodies than is generally taken Notice of by them that underſtand not the Reaſon from whence it proceeds.

In the next Place obſerve, That as the *Baroſcope* predicts only Fair and Foul Weather, ſo that you may be the better directed which of theſe to expect, you muſt ſtill note the riſing and falling of the *Mercury*; for its riſing in any Part of the Glaſs betokens a Tendency to Fair, as its falling down foreſhews an Inclination to Rain and Wet: As for the Words engraven on the upper Part of the *Regiſter Plates*, they are then only to be noted when the *Mercury* removes from Changeable upwards, and thoſe on the lower Part are to be noted only when the *Quickſilver* falls from Changeable downward.

In other Caſes the Words are of no Uſe; for if its Riſing in any Part foreſhews a Tendency to be Fair, and its Falling in any Part, a Tendency to Foul Weather, then it follows, that if it fall from ſettled Fair to Fair, it may yet Rain a little, though the *Quickſilver* ſtill ſtands as high as Fair; the like may be ſaid, if it riſe from the Word much Rain to Rain; for though its Riſing betoken a Tendency to Fair, yet ſince 'tis ſtill ſo low as the Word *Rain*, there may be yet be ſome Wet *Weather*, though not ſo much as there was before the *Quickſilver* began to riſe.

But if the *Mercury* mount upwards from Changeable, then will the *Weather* for the moſt Part be ſuch as the

Words in the upper Part of the Regiſter Plates import; and if from Changeable it falls downs, the *Weather* likewiſe will be much the ſame, as the VVords found in that part do expreſs; but in the *Mercuries* riſing up to Changeable when 'tis below it, or falling when 'tis above it, the VVords as I ſaid before ſignifie nothing.

If the *Mercury* riſes very high, the *Weather* will continue Fair ſo long as it ſtands at that Pitch; and you will not find the *Weather* change much till the *Mercury* falls down a good Space lower: So likewiſe when 'tis fallen down very low, you muſt expect VVet *Weather* during all the time of its ſo continuing; in both theſe Particulars you will be certain, provided the *Wind* and the *Moon* concur.

For both the *Wind* and the Changes of the *Moon* are to be well obſerved in order to make the truer Prediction: And firſt, for the *Wind*, this is found to be of very great Moment; for if the *Glaſs* fall, and the *Wind* ſit in thoſe Quarters, from whence much *Rain* is obſerved uſually to come, as with us about *London* are the *South* and *South-weſt*, then 'tis not to be doubted but *Wet* will follow. On the contrary, if the Glaſs riſe when the *VVind* blows from a dry Quarter of the *Heavens*, as with us are the *North* and *Eaſt*, then 'tis a Hundred to One but the *Weather* will be Fair; but if the *Glaſs* riſes, and the *Wind* be *South*, the Caſe is doubtful: So alſo if it falls, and the *Wind* be *North*, for then it often happens that the *Weather* does not prove always ſuch as the riſing and falling of the *Glaſs* predicts.

As to the *Moon*, 'tis well obſerved by the late Mr. *Gadbury*, That the *Weather* is generally inclinable to *Moiſture* about Three Days before, and Three Days after, both the *New* and *Full Moon*; if therefore the *Glaſs* falls, the *Wind* be *South*, and the *Moon* near the *New* or *Full*, the certainty of *Rain* is ſtill the *greater*.

If the *Mercury* be high in the *Summer-time* when the *Weather* is *hot*, and does of a ſuddain fall down a pretty conſiderable Diſtance, then expect great and ſudden *Storms* of *Rain* and *Thunder* to follow ſoon after.

When the Quickſilver is riſen very high in *Winter*, and the *Winds* ſits then *North* or *Eaſt*, it certainly preſages *Froſt* to enſue, and the ſame will continue as long as the *Mercury* ſtands thus high; but when you ſee it begin to ſink ſomewhat conſiderably, then be aſſured a *Thaw* will quickly follow.

If in a *Froſt* the *Air* becomes overcaſt, and the *Quickſilver* riſes of a ſudden yet higher, when it had ſtood high for a time before, then look for *Snow*, for the Cold above, which is the Cauſe of *Snow*, cauſes alſo the *Air* to become more heavy by Condenſation.

If the *Glaſs* riſe and fall but a little, or if it be unſettled in its *Motion*, it then argues an unconſtant Seaſon, and the *Weather* will not then long continue in one State; the like happens when it is about the Word *Changeable*, or *Uncertain*, for then no true Gueſs can be made what the *VVeather* will be.

The *Mercury* is always obſerved to be loweſt in extream high and ſtrong Winds, that happen when the Air is full of Moiſture; but the Glaſs does no way predict Wind beforehand, for the extream Lowneſs of the Quickſilver happens only at the very Time the Wind blows; and as ſoon as the Wind ceaſes the *Mercury* is then found to riſe apace; but ſuch a Riſe that immediately follows Storms are no Signs of Fair Weather, except it riſes much higher than it was at the Time of the Wind's beginning to blow.

Note, That when Wet is predicted by the Glaſs, or by any other Sign or Token, it generally begins to Rain either when the Moon is in due *South*, or elſe when the Sun comes to be upon the ſame Quarter from whence the Wind blows; and if it Rains not at the Time of the Moon's Southing or Northing, nor when the Sun and the Wind comes together, then 'twill hardly Rain till the ſame Times do again return; which is a good Note in Time of Harveſt, and very ſeldom fails, though it ſometimes may.

Note alſo, that moſt great Changes of the Weather happen with us, either at the New Full Moon; and if the Weather change not then, 'twill hold on as it is till the next New or Full Moon comes: Froſt generally breaks at the Changes, when it does break, and 'tis commonly at the Change or Full that Rain comes, after a dry Seaſon has long continued.

An Addition of ſome Natural Predictions of Fair and Foul Weather, to help to judge right by the Baroſcope: And firſt of Fair Weather.

THE much hooping of Owls, after Sun-ſet, in the *Summer-time*, and in the Night alſo, foreſhews a Fair Day to follow.

Swarms of little Gnats and Flies, ſporting themſelves together, in the Evening, is a certain Token that the Day following will be Fair.

If the Sun ſet red in the Evening, and the Place be free from Clouds, and the next Morning riſes Clear and Bright, theſe are good Tokens that the Day will be Fair.

The Soaring of Kites aloft in the Air is a Sign of Dry and Hot Weather.

When the Bat-Mice are ſeen to fly to and fro, in the Evening, it ſhews that the next will be a Fair Day.

If, in the Morning, Miſts deſcend from the Hills, and ſettle in the Valleys, 'tis a Sign that the Day will be Fair.

If it Rain in the *Summer*, and Horſes and Kine do thereupon leave off feeding, 'tis a certain Sign the Rain will not continue long.

Crows, if they caw or cry early in the Morning, with a loud and clear Voice, it ſhews that the Day will be Fair.

Signs of Rain *and* Wet Weather.

IF, in the Evening, the Sun ſet behind a very dark black Cloud, and her Body appear alſo greater at that Time than uſual, it certainly betokens VVet the next Day.

If VVater-Fowl waſh themſelves much, and dive more than uſual under VVater, and alſo flutter and clap their

Wings, and oil their Feathers more than uſual, 'tis a Sign of Rain.

If Toads are, in the Evening, found leaping in the Paths or High-ways, or if the great Black Houſleſs Snails are found creeping about more than uſual, it foreſhews Rain.

An unuſual Circle of Light about the Moon or Stars, when no Miſt or Fog appears below, is a ſign of Rain ſoon to follow.

If the Sun, at her firſt riſing, or ſome Time after, ſhine wateriſh, that is, paler than ordinary, 'tis a ſign of a Wet Day, eſpecially if the Air be ſoon after obſcured with thick Clouds.

If in the *Summer*, in a Fair Clear Day, you perceive the Clouds to gather of a ſudden on all Sides, and appear black and curled, then prepare your ſelf for Storms of Rain and Thunder ſoon after.

Hogs crying in an unuſual manner, and running unquietly up and down, with Litter in their Mouths, foreſhews Rain and Storms at Hand.

If Crows cry much in the Evening, 'tis a ſign of Rain the next Day.

Any of theſe, or the like Signs, happening in the *Summer* time, will, if the Baroſcope concur, help you to make the more certain gueſs at what Weather will after enſue, eſpecially if the Glaſs be at *Changeable* and *Uncertain*, for then by theſe you may the better gueſs at what Weather will follow. Some particular Places have alſo Signs of Rain and Fair Weather, which others have not, which obſerved, together with the Glaſs, may make your gueſs more certain than they can otherwiſe be; the Nature of Countries alſo differ, for whereas in *England*, eſpecially near *London* and the Southern Parts, a South or South-weſt Wind always brings moſt Rain, and a North or Eaſt Wind Dry Weather; on the contrary, at *Edenburgh* in *Scotland* a South Wind brings the Faireſt Weather, and a North-eaſt the greateſt Wet; theſe things conſidered, every Man that lives in Countries differing in Temper from that for which which theſe Rules ſerve, ought to frame Rules to himſelf, by obſerving the Changes that follow the Glaſs's Riſing and Falling, the Change of the VVind, and the Southing of the Moon.

Note, If the latter End of *February* and the Beginning of *March* be conſtantly Dry, it betokens a very Dry *Summer*. Alſo a hard Froſty and Snowy *VVinter* makes the Year following to be very Plentiful and Healthy, but a Warm and Moiſt *VVinter* makes the *Summer* after to be very Sickly.

Some Uſes of the Spirit Weather-Glaſs.

THE ſuddain Riſing of the Spirit in the Day, in *Summer*, foreſhews an immediate Approach of Thunder and Storms of Rain, and in *VVinter*, Snow.

If it riſes much in the Day and falls but little in the Night, then expect the Day following exceſſive Heat, if not Thunder and Storms.

If it riſes never ſo little in the Night-time, expect next Day either Rain or Snow, as the Seaſon is.

If it riſes no more in the Day than it falls in the Night, 'tis a Token that the Air is Temperate, as to the Heat and Cold.

If it falls in the Day-time, and the VVeather be Fair, expect a Froſt the next Night. The like happens alſo generally when the Liquor is very low.

The more it riſes or falls at any time the more remarkable will that Change of VVeather be which follows.

All the other Uſes of it are only to ſhew the preſent Temper of the Air, as to Heat and Cold, and farther than this my Experence has not as yet led me, neither by Enquiry do I find any other uſeful Obſervations made on them.

I ſhall only add, That theſe Glaſſes might be made as ſtrong as the Tube of a Quickſilver VVeather-glaſs, provided the Ball be proportionable to the Bore only. It may be if the Glaſs were thicker they would not move ſo nicely; but this would not ſignifie much, becauſe little Judgment can be made from ſmall and little Alterations.

JUſt when the laſt Sheet was ready to be printed off, that which follows was communicated to me by Mr *VVatſon*, which in reſpect of its Nature, being not only plain and uſeful, but alſo free from all Objections that Tables may be liable to, I have thought fit to add it hereunto, upon his Recommendation, and in the Words penn'd by himſelf.

SIR.

I Rather communicate this to you, becauſe many Gentlemen have the Convenience of Places fit for this way of Obſervation, which I take to be the moſt exact VVay yet found to adjuſt a Pendulum Clock well. If you think it may be ſerviceable to thoſe that are the moſt exact and curious in Time-keeping, you may do well to inſert it in that Laborious and Curious Tract of the Equation of Natural Days, *that you are now publiſhing. I am,*

Your real Friend,

and Humble Servant,

S. VV.

The Way of finding how much a Pendulum Clock *has gained or loſt in a Day, Week, or a Month, to the Nicety of Two or Three Seconds,* &c.

N.	h.	′	″	N.	h.	′	″	N.	h.	′	″
1	0	3	56	12	0	47	11	22	1	26	30
2	0	7	52	13	0	51	7	23	1	30	25
3	0	11	48	14	0	55	2	24	1	34	21
4	0	15	44	15	0	58	58	25	1	38	17
5	0	19	39	16	1	2	54	26	1	42	13
6	0	23	35	17	1	6	50	27	1	46	9
7	0	27	31	18	1	10	46	28	1	50	5
8	0	31	27	19	1	14	42	29	1	54	1
9	0	35	23	20	1	18	38	30	1	57	57
10	0	39	19	21	1	22	34	31	1	1	53
11	0	43	15								

TAke a Piece of thin Braſs, and file therein a Slit or Notch, about half a quarter of an Inch deep, knock the End of it into ſome Poſt in your Back-ſide, or elſe in ſome Window, that ye think convemient, then look through the Notch at any Star of the firſt or ſecond Magnitude, and wait till the Star comes to the Edge of any Chimney, or the Side of any Houſe, and you will ſee the Star vaniſh in a Moment ; then mark what your Clock is at when the Star vaniſhes: Then at any other Night afterwards (as the next Night, or a VVeek or a Month afterwards) wait for the ſame Star again till it vaniſh behind the Chimney or Houſe, as before, and then obſerve what your Clock is at, then your Clock ſhould ſhew the ſecond time of vaniſhing ſo much ſooner than the firſt, as this Table ſhews; now the farther off the Chimney or Wall is, the more exact will the Obſervation be; let the Obſervation be made in any part of the *Eaſt*, *South* or *VVeſt*, but little towards the *North Pole*, becauſe the *Polar Stars* are not ſo fit for this Purpoſe.

EXAMPLE.

Suppoſe a Star vaniſhes this Night at Nine Hours Three Minutes and Four Seconds by my Clock, and Eight Nights after I obſerve it again, and it then vaniſhes at Eight Hours Thirty-four Minutes and Forty-two Seconds by my Clock; againſt Eight Nights in the Table, I find Thirty-one Minutes Twentyſeven Seconds; that is, ſo much ſooner ſhould the Star vaniſh at the ſecond Obſervation 9h. 3′ 4″. than it did at the firſt; therefore ſubſtracting 31′. 27″. from the firſt Obſervarion, there's left 8 h. 31′ 37″, the true Time that the Clock ſhould have been at in the ſecond Obſervation; therefore ſeeing the Clock was then at 8 h. 24′ 32″, it has gained 2′ 55″.

FINIS.